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VOLUME XXXVII, 1944

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ANNALS  
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Volume XXXVII

MARCH, 1944

No. 1

THE TEMPERATURE RELATIONS OF THE IMMATURE  
STAGES OF THE MALARIAL MOSQUITO, *ANOPHELES*  
*QUADRIMACULATUS* SAY, WITH A COMPARISON  
OF THE DEVELOPMENTAL POWER OF CON-  
STANT AND VARIABLE TEMPERATURES  
IN INSECT METABOLISM<sup>1, 2</sup>

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INTRODUCTION

For half a century medical men, biologists, engineers, and many other anti-malarial workers have increasingly endeavored to bring the world's most devastating disease, malaria, under control. Its widespread prevalence in the southeastern United States is attributed largely to the activities of the mosquito vector, *Anopheles quadrimaculatus* Say, which serves as the definitive host of the *Plasmodium* parasites which are the causative agents of the malady. A principal method in the control of the disease throughout the world has been the prevention of breeding of anopheline mosquitoes. Although the literature on these forms has grown very rapidly, few attempts have been made to determine their reactions to isolated and controlled environmental conditions. Field investigations have been very numerous, but these have been under such a complexity of circumstances that only a very fragmentary knowledge has been obtained concerning the specific factors and combinations of factors that contribute to their success in nature. It has

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<sup>1</sup>This paper is a revision of a dissertation presented to the Faculty of the Graduate School of The Ohio State University in partial fulfillment of the requirements for the degree of Doctor of Philosophy. It is a joint contribution from the Department of Zoology and Entomology of the Ohio State University and the Department of Entomology of the University of Delaware, the work at Delaware being carried on under a Funnell project entitled "Mosquito Investigations."

<sup>2</sup>The author wishes to express his appreciation to Dr. Z. P. Metcalf for his encouragement in the early pursuit of the general problem; to Drs. D. M. DeLong, F. L. Campbell, and Harold E. Waters for valuable advice during the major part of the investigation; to Dr. Paul L. Rice, and Harvey L. Chada for suggestions concerning the manuscript; and to Fenton T. West for making some of the observations.

been generally recognized in recent years that it is essential to make a thorough, basic study of the ecology of the species concerned before the greatest mosquito control achievements can be accomplished.

This paper is the result of an investigation into one of the foremost physical factors in the limitation of *Anopheles* throughout the world. This factor is temperature. For the first time, a comprehensive description of the developmental reactions of *A. quadrimaculatus* to temperature is presented.

The relation of temperature to various aspects of the ecology of poikilothermic animals in general probably has received more attention than any other feature of the environment. As Chapman (1931) stated, "It probably affects animals more evidently and in more ways than any other factor." Réaumur (1736) recognized that there is a quantitative relationship between the activities of organisms and temperature, and first suggested the thermal constant concept. In his excellent discussion of the relation of climate to insects, Uvarov (1931) stated that over 1300 papers were reviewed by him, and that this figure is only representative, for hardly a paper has been published in economic entomology without some data concerning temperature. Merriam's work (1894) is an example of the contribution of temperature studies to human endeavor. His major conclusions, based upon temperature summation data, even though unsound in many cases, unquestionably gave tremendous impetus to the study of the factors governing the geographical distribution of organisms and to biological and agricultural advancements in general. Bělehrádek (1935) published what is perhaps the most recent extensive paper on the temperature relations of living matter. Bachmetjew (1901, 1907), Davenport (1908), and Kanitz (1915) also have contributed important earlier papers.

In spite of the considerable attention that has been given to the temperature ecology of insects, much remains to be learned, and many concepts need to be placed on a more generally acceptable, firm basis. Three considerations of primary importance are taken up in this work: 1. The temperature relations in the development of a thermally unspecialized insect, *A. quadrimaculatus*, are followed independently for all the developmental stages, and differences and similarities between stages are established. 2. The relative developmental powers of constant and variable temperatures are viewed in the light of the catenary formula, concepts advanced by Blackman (1905) in the field of botany, and previous and present experimentation on the subject. 3. An attempt is made to further the acceptance of the catenary formula of Janisch (1925) as an adequate expression of the time-temperature relationship of insect development.

Any attempt to evaluate the metabolic power of variable and constant temperatures must be based upon a great number of experiments. Only after the relation of the constant throughout all limits of survival has been worked out can a suitable comparison be made. In order to attach to this comparison a basic ecological or physiological significance, it is necessary to use a species, or developmental stage, that does not represent a high degree of specialization to the temperature factor. If development involves a special demand upon the temperature environ-

ment, such as the breaking of diapause, this development cannot be considered critical in generalized comparisons of the variable and the constant.

It is for this reason that a representative of the tropical and sub-tropical genus *Anopheles* Meigen was chosen in the present effort. The additional fact that the development of this species, *A. quadrimaculatus*, occurs in a medium of water adds to its utility in such a study. In nature, the changes in the water temperatures where this form abounds are much slower than are air temperatures. During much of the summer, at the height of the breeding season, the day and night water temperatures certainly do not vary to the extent of the laboratory variations imposed upon this species in the present investigation. Therefore, any differences in development that are found cannot be attributed as readily to the normal adaptation of the species, as might be the case with most terrestrial, temperate climate insects.

### CONCEPTS ON THE RELATION OF TEMPERATURE TO DEVELOPMENT

Even today there is no general acceptance of a mathematical means of expressing the developmental reaction of poikilothermic organisms to temperature changes. It is necessary, therefore, to re-examine the relation of constant temperature to the metabolism of these forms. Since, from simple physics and chemistry, it is known that temperature greatly affects chemical and physical phenomena, it is not surprising to find it playing an important part in the life of organisms. The mechanists have maintained that all biological processes have explanations that are fundamentally assignable to the laws of chemistry and physics. Regardless of the truth of such a view, it is certain that many such processes do have their explanations in physical and chemical laws. Solution, gelation, coagulation, surface tension, diffusion, imbibition and viscosity are a few of the more basic physical phenomena that are greatly affected by temperature. All chemical reactions are subject to changes with temperature. When it is remembered that temperature may affect each process to a somewhat different degree and that changes of varying degree and kind may take place in an organism at the same or at different times, then it is not alarming that it has been impossible to fully explain the effects of temperature in ecology or physiology. It is, rather, most astounding that such direct correlations and effects are observable!

**Early Formulæ.** As early as 1862, according to Bělehrádek (1935), Berthelot first used a formula for the rate of some chemical reactions in relation to temperature, from which the  $Q_{10}$  rule may be derived. However, van't Hoff (1884) proposed a new equation which is the mathematical formula of the statement that for each temperature rise of  $10^{\circ}\text{C}.$ , the velocity of most chemical processes increases two to three times. This formula may be expressed as

$$\frac{K_t + 10}{K_t} = Q_{10} = 2 \text{ to } 3$$



However, he showed that this  $Q_{10}$  may vary from as low as 1.20 to as high as 7.14. Therefore, biologists are in error in applying the expression "van't Hoff's law" to biological phenomena. The effect of increased temperature is thus expressed as a multiplication of a known rate at a lower temperature.

Argo (1939) pointed out that, even though the temperature/respiration curves of Krogh and the temperature/velocity-of-development curves of Krogh, Shelford, Janisch and others conform to the reciprocal of the catenary of Janisch, temperature/respiration studies on adult insects have failed to support such catenary curves and instead do support simple exponential curves of the van't Hoff or Arrhenius type.

The "law of Arrhenius" is derived from the "van't Hoff Law." Arrhenius (1889) used the constant  $\mu$  to bring  $Q_{10}$  closer to 2. In chemical reactions this constant (the thermal increment of Crozier) varies from 4,000 to 35,000, according to Crozier (1924). This latter author utilized the thermal increment to explain the underlying reaction governing complex biological processes. However, his work has found little approval. The explanation of complex biological processes, involving many limiting physical factors as well as chemical ones, invariably in terms of simple oxidative reactions, and necessitating the view that the reaction curves have sharp changes in velocity at "critical points," cannot be accepted at present. The formula of Arrhenius may be expressed as

$$K_1 = K_0 e^{\frac{\mu}{2} \left( \frac{T_1 - T_0}{T_1 T_0} \right)}$$

where  $K_1$  and  $K_0$  are velocities at the absolute temperatures  $T_1$  and  $T_0$  respectively,  $\mu$  is the constant, and  $e$  is the base of natural logarithms.

The rule of thermal summation, suggested by Réaumur (1736) and given quantitative expression by Boussingault in 1851 (according to Bělehrádek, 1930), is the most familiar rule of temperature reaction of insects. The works of Hennings (1907), Peairs (1914), Krogh (1914), Blunck (1924), Bodine (1925) and others are well known examples of the application of this rule. It is, simply, that the temperature, expressed in effective degrees, multiplied by the time required is a constant. For medial temperatures this rule is a good practical method of expressing the relation of temperature to insect development. According to this rule, the velocity of reaction is a straight line when plotted against temperature. Prochnow (1907, 1908), Krogh (1914), Shelford (1927), and many later authors have now firmly established that there are significant departures from the straight line at both ends of the biokinetic scale. Shelford (1929) accepts this expression as conforming to the observed facts only for about one-third of the range of temperatures (medial temperatures) compatible with life.

The formulae so far mentioned fall into the following two categories:

1. Exponential formulae based on the velocity of chemical reactions of various types (van't Hoff's rule, Arrhenius' formula, and Janisch's catenary formula or "exponential law").
2. Those where the velocity is expressed as a linear function of temperature (Réaumur, Krogh, Peairs, Bělehrádek, Wardle and others).

*The Catenary Formula.*—Since it has been repeatedly shown that the value of a degree is not developmentally equivalent everywhere in the biokinetic scale, it is obvious that the straight-line relationship formulae have no basis either empirically or theoretically. As a result, they fail entirely as a means of describing the reaction curve at the extremes of temperature.

The catenary curve of Janisch (1925, 1932) is the mathematical formula that seems most adequate as an expression of the relation of temperature to the development of insects. Janisch's formula is derived directly from the "exponential law" of that author (1925). This "law" is based on the law of mass action and hence, "The fact that the influence of temperature in chemical processes can be expressed by an exponential curve—i. e., that the velocity constant is an exponential function of the temperature—is a law on a theoretical basis and not merely an empirical rule." Though both  $\mu$  and  $Q_{10}$  have proved inadequate as expressions of the relation of temperature to biological processes, a catenary curve has been shown to be a good expression of this relation by Cook (1927), Menusan (1934) and Janisch (1932). The present effort is further proof of the utility of the curve. The reciprocal of this catenary curve, plotting velocity of reaction against temperature, has the characteristic S-shaped form of the biological curve. It is almost identical to the thermal unit curves of Shelford (1929). The formula of this catenary curve is

$$t = \frac{m}{2} (a^T + a^{-T}),$$

where  $t$  = time,  $m$  = developmental time at the empirically determined optimum,  $a$  is an empirically established constant which determines the slope of the curve, and  $T$  is the temperature in degrees above or below the optimum.

This curve is derived by the addition of two simple exponential curves. Janisch (1925) states, "... this means biologically that two things working opposingly are added, a positive function, the acceleration of developmental processes through rising temperature, and a negative function, the retardation and injury in the processes of development." Below the optimum the accelerative effect is largely determinative and above the optimum the opposite is the case. It is seen, therefore, that certain factors which retard development are not suddenly operative just as the optimal temperature is passed, but are present as contributing elements even at very low temperatures. These factors assume an ever-increasing role in the velocity of the reaction as the temperature is increased, gradually assuming the dominant function. Above the optimum, the accelerating factors are still operative, but now decrease in importance in conditioning the observed velocity.

The writer has never held with the generally accepted view that death at high temperatures is associated with coagulation of protoplasm. This theory also is in opposition to such a view. Observations on the general symptoms of approaching death at high temperatures, for *A. quadrimaculatus*, suggest that with proper techniques it might be possible to show that death at high temperatures is related to starvation at lower temperatures. It seems possible that, at barely lethal high

temperatures, nutritive substances are oxidized so rapidly that the supply cannot keep pace and no net increase in mass or necessary developmental change can occur. Digestion, diffusion, transportation in the blood stream, or the removal of waste products of metabolism may be partly limiting.

Regarding this catenary formula, Harries (1939) stated, "Although the equation has the advantage of being applicable to data through a wide range of temperature, the descriptive advantage in flexibility obtained through the use of numerous constants gives an indefinite character for the shape of the regression curves." However, it remains a fact, admitted by Harries, that this formula is the only one yet advanced which is generally applicable to the complete reaction data. It is appropriate also to question the criticism that the formula lends an indefinite or plastic character to the reaction velocity curve. Plasticity is an inherent necessity of any formula applicable to both the rising and descending arms of the multitudinous variety of developmental curves. Such a formula must be conformable to the fact that organisms themselves possess the character of endless variability in response. The slope of the velocity curve shall therefore be dependent upon where in the temperature scale the optimum and the "threshold" (or an equivalent concept) lie for the particular species or stage. It is necessary, therefore, that a parameter dependent upon the optimum and one dependent upon the "threshold" (or else upon the slope of the curve) be included in the formula. Essentially all formulae used in such studies have some feature which utilizes the concept of the "threshold" or other empirically determined value. Since they do not encompass the post-optimal arm of the velocity curve, they do not possess features concerning the optimum.

The constants in the catenary formula,  $a$  and  $m$ , are, therefore, necessarily determined from the empirically established data. Sufficient points must be established in the vicinity of the optimum to establish the optimal temperature and the developmental time at that temperature, and also at some point in the medial temperature section of the velocity curve so as to establish the developmental time at a given temperature in that vicinity. If the reaction is adequately determined at two such positions, the remainder of the reaction curve can be generally predicted by the resultant catenary curve and/or its reciprocal.

In the present work, the constant for slope,  $a$ , was determined by averaging the velocities at all medial constant temperatures, converting to the corresponding time value, and solving for  $a$  of the catenary formula. Due to the small number of points established in a given series in the vicinity of the optimum,  $m$  had to be established largely by visual interpolation between points.

*Variable and Constant Temperatures.*—For many years it has been known that variable and constant temperatures produce different rates of insect metabolism. Chapman (1931) and Imms (1937) have reviewed the literature on this subject. These authors state that the data were not conclusive as to whether exposure to variable temperatures results in a rate of development, or general metabolism, greater than does exposure to the numerically equivalent constant temperatures.

The probable general explanation of the reason for an increased rate of metabolism under variable temperatures, compared with constant, was discussed by Blackman (1905), several years before the subject received attention in entomology. As a result of his botanical studies on the carbon assimilation of cherry laurel under different temperatures, he stated the following conclusions:

1. At high temperatures (30° C. and above for the leaves of cherry laurel) the initial rate of assimilation cannot be maintained, but falls off regularly.
2. The higher the temperature the more rapid the falling off.
3. The falling off at any given temperature is fastest at first and subsequently becomes less rapid.

Bayliss (1913) looked upon these conclusions as a complete explanation of the effects of temperature upon enzyme reactions. Cook (1927) and Kanitz (1915) reviewed this work of Blackman, and the latter author disagreed with the conclusions. Cook's work on the effect of variable temperatures on the metabolism of *Porosagrotis orthogonia* Morr. seems to be in agreement with the principal thesis. The results of the present investigation also will be shown to be in conformity.

Statements by Peairs (1914, 1927), Janisch (1925, 1932), Cook (1927), Shelford (1927, 1929), and Parker (1930), reveal that insect development under variable temperatures is faster than that under constant. Peairs found that development was as much as 12 per cent faster under the variable, for blowfly larvae, if the temperature was changed each six hours. The average acceleration, however, was about 7 per cent under several conditions of alternated temperatures. Shelford (1929) stated that the pupal stage of the codling moth, *Carpocapsa pomonella* L., is about 7 per cent shorter under variable temperatures. Cook (1927) found a 37 per cent increase over the constant for *P. orthogonia*, and Parker (1930) increases of 70 and 80 per cent for the development of the eggs of the grasshoppers, *Melanoplus mexicanus* Saussure and *Camnula pellucida* Scudder. Parker also revealed that the total food consumed in completing growth by the nymphs of *M. mexicanus* (Saussure) was only two-thirds as great under variable temperatures as under constant. Cook further showed that the metabolic rate, as exhibited by CO<sub>2</sub> output, is faster under variable temperatures. Shibata (1934) found that the percentage of sexual and parthenogenetic females and also the sex ratio of *Callipterus kurikola* Mats. was greatly affected by rearing under different conditions of alternating temperatures.

On the other hand, Ludwig (1928), as a result of work on the developmental rate of the Japanese beetle, *Popillia japonica* Newman, reached the conclusion that only if the high temperature is between the threshold and the optimum and the low temperature is below the threshold does an acceleration under the variable occur. Headlee (1914, 1929, 1940, 1941) also has presented conclusions in repudiation of the claim of a fundamental increase in the metabolic power of the variable as compared to the constant. He (1914) found a slightly higher rate of reproduction of the grain aphid under variable temperatures, up to 20° C. Above this temperature, however, he found the constant to be much more powerful. The use of temperatures above the optimum, in

variable units having a mean above 20° C., probably accounts for the lower metabolic power of the variable above that average value. His results (1940) showed constant temperatures to be far more powerful than variable on the development of codling moth pupae, *C. pomonella* L. and also for the development of the yellow fever mosquito, *Aedes aegypti* L. In the first case the results are contradictory to the work of Shelford previously cited. Both 90 and 100° F. (the high temperatures used) are post-optimal for the mosquito and the results, therefore, do not refute the claim of an acceleration of development under variable temperatures.

Headlee (1941) published data very different from his earlier work on the same mosquito. In this case he found a decided increase in the velocity of development under the variable condition, where the temperature varied daily from 50 to 80° F. This series is of the greatest value in the present consideration, for both the maximum and the minimum were clearly between the threshold and the optimum. Headlee omitted this series from discussion and purported to show that the acceleration of the 60 to 90° F. variable lot is explained on the basis of the "... speed of accumulating the thermal constant." In so explaining, he apparently made an error in his calculations. Furthermore, it seems perfectly obvious to the writer, having studied his apparatus as well as his data, that his variable and constant temperature lots accumulated thermal units at exactly the same rate. In listing his summary in degrees he utilized 31 temperatures, but in determining the exposure per day for each temperature, he used only 30. And again, he utilized 14 temperatures but determined the daily exposure for each on the basis of 13. In each case the error involved is sufficient to completely nullify the conclusions from the calculations. He further stated that, "... the underlying and governing factor of such differences as exist in the variable and constant temperatures is the accumulation of the required amount of temperature, regardless of whether the temperatures in question come from constant or variable sources." This statement appears to be unfounded, even from consideration of his data alone. The works of many other authors and the results herein presented are certainly not compatible with this viewpoint.

## METHODS

During all the work herein reported, 25 eggs or newly-hatched larvae of *A. quadrimaculatus* were used in each experimental lot of insects. A total of six experiments, following the development from stage to stage, were conducted for the larval and pupal stages. Each experiment involved approximately eight lots exposed to constant temperature and from ten to fifteen lots exposed to alternating high and low temperatures; a total of 130 lots and 3250 larvae. Except when otherwise stated, the figure used to indicate a developmental velocity is based upon the average time required for the first half to transform. There is every reason to believe that for this species, under these conditions, such data are more critical with respect to the temperature factor than are data based upon the average time required for all to transform, since the latter half transforming are more apt to be subject to a limiting food factor than the first half.

In these experiments, two temperature-controlled water-bath cabinets were used, one in the Department of Zoology and Entomology of the Ohio State University and the other in the Department of Entomology of the University of Delaware. Temperatures were accurate to  $\pm .5^{\circ}$  C. for each compartment. Readings were taken twice daily with a U. S. Bureau of Standards thermometer, graduated to one-tenth degree Centigrade. It was possible, therefore, by averaging these readings, to get results that were probably accurate to  $\pm .1^{\circ}$  C. for a total period of development.

The variable temperature lots were moved by hand at stipulated times. The mosquitoes were reared in containers having celluloid walls and bandage cloth bottoms. The culture water, therefore, was not moved and the insects very quickly came to the temperature of the new compartment. This probably produced some shock, but apparently not a great deal, for lots that were moved twice daily developed faster than those shifted only once daily.

The pH values varied from 6.9 to 7.5, which is generally accepted to be in the vicinity of the optimum for this species. Senior-White (1926) showed that the range of tolerance of the genus *Anopheles* to H-ion concentration is relatively large. No interference from this source was encountered.

The larvae were fed powdered dog biscuit, recommended by Crowell (1940). Hinman (1930) showed that *Anopheles* exhibits little food preference and can successfully utilize a great variety of food substances. Furthermore, microscopic observations of culture water revealed an abundance of Infusoria at all temperatures. Larvae reared in water changed daily, which never supported the larger Infusoria such as *Paramecium*, developed in nearly the same period of time as those reared in normal cultures. These protozoa apparently supplemented the dog biscuit diet, but only slightly, particularly between feeding times. Inasmuch as this was a highly extreme case, it is certain that a comparable food difference in any of the experimental lots did not exist.

#### REACTION OF THE IMMATURE STAGES TO CONSTANT TEMPERATURES

In Table I and figure 1 is presented a comprehensive analysis of the reaction of the immature stages of *A. quadrimaculatus* to constant temperatures. The observations on development for these experiments were made at intervals of six hours. Approximately 25 individuals were used in each experiment, and duplicate experiments were conducted at most temperatures. "Optimal temperature" is used as the temperature at which the rate of development is highest. However, it is recognized that this is a developmentally optimal temperature only, and may bear no rigid correlation with the optimal temperature for maximal expression of biotic potential, considering the total life span. Equally as limited in its use is "optimal survival temperature," which is the optimum used by Price (1940).

In figure 1, both the time required to complete the stage (plotted against temperature as the catenary curve) and the velocity of development (plotted against temperature as the reciprocal of the catenary curve) are presented for each instar. The reciprocal has the sigmoid

TABLE I  
THE DEVELOPMENT OF THE IMMATURE STAGES OF THE MALARIAL MOSQUITO, *Anopheles quadrimaculatus* SAY,  
UNDER CONSTANT TEMPERATURES

Stage	Temperature, Time and Velocity	Observed Data										Calcu- lated Values at Optima
Egg Stage	Temperature in °C . . Time in Hours . . . . . Developmental Velocity (1/Time) . . . . .	10.0 492 0020	14.5 192 0052	18.3 108 0093	22.0 69 0145	25.4 46 0217	28.6 39 0256	31.8 34 0294	34.8 34 0294	35.1 33 0303	33.3 33 0303	
First Instar	Temperature in °C . . Time in Hours . . . . . Developmental Velocity (1/Time) . . . . .	12.1 275 0036	14.6 168 0060	18.8 111 0090	21.7 68 0147	24.4 53 0189	27.0 41 0244	29.4 35 0286	32.5 31 0323	35.1 33 0303	32.5 30 0333	
Second Instar	Temperature in °C . . Time in Hours . . . . . Developmental Velocity (1/Time) . . . . .		14.6 144 0069	18.9 96 0104	21.7 54 0185	24.5 35 0286	27.2 33 0303	29.7 30 0333	32.3 24 0417	34.7 29 0345	32.2 26 0385	
Third Instar	Temperature in °C . . Time in Hours . . . . . Developmental Velocity (1/Time) . . . . .		14.4 156 0064	18.9 87 0115	21.7 47 0213	24.5 43 0233	27.2 36 0278	29.7 34 0294	32.5 32 0313	34.7 33 0303	31.0 30 0333	
Fourth Instar	Temperature in °C . . Time in Hours . . . . . Developmental Velocity (1/Time) . . . . .	12.1 365 0027	15.7 180 0056	18.9 119 0084	21.9 96 0104	24.5 69 0145	27.0 62 0161	29.5 56 0179	32.2 56 0179	34.3 70 0143	30.0 55 0182	
Pupal Stage	Temperature in °C . . Time in Hours . . . . . Developmental Velocity (1/Time) . . . . .	12.1 206 0049	15.6 120 0083	19.2 89 0112	22.0 59 0169	24.7 46 0217	27.2 39 0256	29.6 46 0278	32.2 36 0278	34.4 39 0256	30.5 35 0286	
Eclosion to Emergence	Temperature in °C . . Time in Hours . . . . . Developmental Velocity (1/Time) . . . . .	12.1 1572 0006	15.1 768 0013	19.2 501 0020	22.0 319 0031	24.7 245 0041	27.2 210 0048	29.6 190 0053	32.3 178 0056	34.6 203 0049	31.0 176 0057	

form of the biological curve, and, in fact, is preferred in such studies, because it places greater emphasis upon the critical positions of the biokinetic scale, without changing the fundamental relations. The observed points are plotted only as velocities, but the developmental time at a given temperature can be read directly from the catenary curve itself. In Table I are presented the observed data and the calculated data at the optima.

The following paragraphs are devoted to the discussion of the reactions of the several stages to constant temperatures.

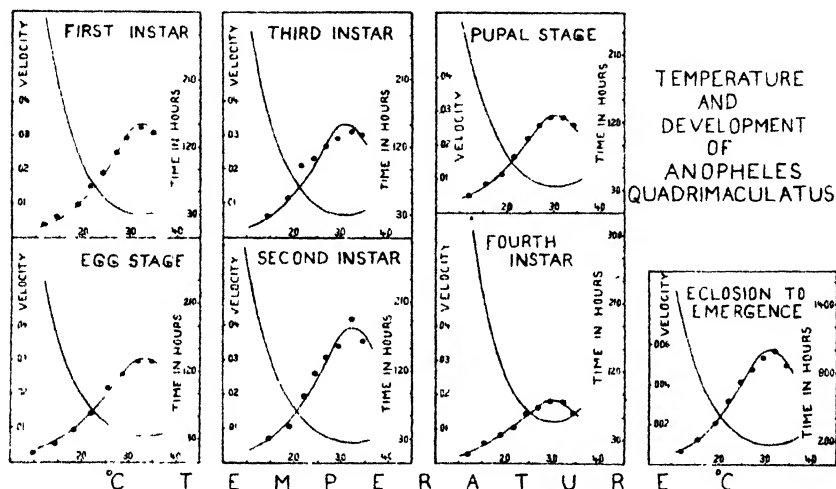


FIGURE 1. Developmental reaction of the immature stages of *Anopheles quadrimaculatus* under constant temperatures. Both the catenary,  $t = (m, 2) (aT + a^{-1})$  and its reciprocal are plotted. In this formula,  $t$  = time,  $m$  is the time required at the optimum,  $a$  is a constant, and  $T$  is the temperature in degrees Centigrade above or below the optimum—based on average emergence. All curves are for the "Wilson Dam, Alabama Strain." The constant,  $a$ , is 1.130 for the egg stage, 1.155 for the first instar, 1.145 for the second instar, 1.155 for the third instar, 1.155 for the fourth instar, 1.145 for the pupal stage, and 1.150 for the period from eclosion to emergence. The constants,  $a$  and  $m$ , were determined in the manner described on p. 6.

**Egg Stage.**—The embryonic development of this mosquito has the highest optimal temperature of any stage—33.3° C. The time required at this temperature, as derived from the catenary curve, is 33 hours. The observed data for 8 temperatures are presented in Table I, and graphically in figure 1. The observed time from deposition of the eggs to hatching varied from 492 to 34 hours as the temperature varied from 10.0 to 31.8° C. It can be seen in figure 1 that the departures of the observed points from the curve are not great.

**First Instar.**—For the first instar the optimal temperature was 32.5° C. The hypothetical time required to complete the stage at this temperature, as derived by use of the catenary formula, is 30 hours.



The observed data for the 9 temperatures are presented in Table I and figure 1. The observed time required to complete the stage varied from 275 to 31 hours as the temperature varied from 12.1 to 32.5° C. It should also be noted that those larvae which completed the stage at 12.1° C. probably represented a small minority of very vigorous individuals, which, unlike the others, were able to utilize the small amount of thermal energy available to them and complete the necessary processes of development. The drop in the velocity of development above 32.5° C. is in accord with the hypothetical curve. The departures of the observed points from this curve are relatively small.

*Second Instar.*—The optimal temperature for the second instar was 32.2° C, the time required to complete the stage at this temperature, as derived from the catenary curve, being 26 hours, the shortest of any stage. Table I and figure 1 present the observed data at 8 temperatures. The observed time required for this stage also varied greatly, from 144 to 24 hours as the temperature varied from 14.6 to 32.3° C. When it is considered that the threshold of larval development for this species is about 7° C., it is safe to predict a developmental time at a temperature of 12.0° C. The hypothetical time required at this latter temperature would be 210 hours. The general form and steepness of the curve, as well as the optimal temperature, for the second instar is, therefore, notably the same as for the first. Though the departures of the observed data from the hypothetical curve are greater in this case, when it is considered that the observations were made only at intervals of 6 hours, the discrepancy is of little concern.

*Third Instar.*—The optimal developmental temperature for the third instar was 31.0° C. The hypothetical time required at this temperature, as taken from the catenary curve, is 30 hours. Observed data at 8 temperatures are presented in Table I and figure 1. The time required at the lowest temperature, 14.4° C., was 156 hours, while only 32 hours were required at 32.5° C. Again it is safe to predict a hypothetical developmental time of about 240 hours at a temperature of 12.0° C. The form of the velocity curve is identical with that for the first instar, but the numerical velocity values for the medial temperatures were greater, indicating that this stage was completed in somewhat less time than was the first instar.

*Fourth Instar.*—The optimal temperature for the fourth instar was 30.0° C. The time required at this temperature, as derived from the curve in figure 1, is 55 hours. A significant difference in the developmental curve for this stage, as compared to those of the other stages, is that the time involved is nearly double that of the other instars. This is to be expected. It is general knowledge that the fourth instar is the one in which a great portion of the body size is attained and which requires much more time in its completion. This stage, as here considered, includes the prepupal form. The same relationships of the other instars exist in this double stage. The time factor alone is different. By lengthening the developmental velocity axis in figure 1 to twice its present dimensions, while holding the temperature axis the same, a velocity curve would result that would be essentially the same as the others. The observed data at 9 temperatures are presented in Table I

and figure 1. The observed time required to complete the stage varied from 365 to 56 hours as the temperature varied from 12.1 to 29.5° C.

**Pupal Stage.**—The optimal temperature for the development of the pupal stage was 30.5° C., the required time, as derived by use of the catenary formula, being 35 hours. As with the fourth instar, the completion of the pupal stage requires somewhat more heat energy than do the first, second, and third instars. However, the time involved is not nearly so great as for the fourth instar. The empirical data for 9 temperatures are presented in Table I and figure 1. The observed pupal period varied from 206 hours at 12.1° C. to 36 hours at 29.6° C. There are no significant changes from the considerations as expressed for the other stages.

**Ecdysis to Emergence.**—The four larval instars and the pupal stage are here considered together as the developmental stage, thus omitting the egg stage. The optimal temperature was 31.0° C., the time required from newly-hatched larvae to emergence of adults being 176 hours, or 7.3 days, as derived from the catenary curve. The general action of temperature upon the velocity of development of this mosquito is presented in figure 1. The observed data for 9 temperatures are presented in Table I, the time required from ecdysis to emergence varying from 1572 hours, or 65.5 days, at 12.1° C. to 178 hours, or 7.4 days, at 32.3° C.

**Discussion.**—The position of the developmentally optimal constant temperature in successive stages in the development of an unspecialized species should have a direct bearing upon the whole problem of the relative power of variable and constant temperatures in metabolism studies. Parker (1930) showed that the optimal temperature and the general temperature relation for eggs of *M. mexicanus mexicanus* were far different from the relations of the nymphs. This raised the question as to whether temperature studies should be confined to a single stage.

If the optimum temperature changes from one instar to another, it should change in some consistent manner. If the value of a high constant temperature is at a maximum only at the beginning of exposure and falls off with time, it would be expected that the earlier instars of a lot of insects which were held at a given pre-optimal high temperature throughout their entire development would have a higher optimum than the later instars. This is because they would have derived the maximum benefit from the initial exposure to the high temperature before the accumulative injurious effect of the high temperature has made itself felt to a great degree. The species of grasshopper studied by Parker is not a suitable example for such consideration. He has shown that the stimulating effect of cold temperatures on the hatching of the eggs of this species is tremendous. The egg stage occupies an entirely different ecological position in the cycle of this species from that of the nymph. Each is adapted to the respective physical conditions which normally prevail during the development of that stage. Hence, the fact that the optimal temperature for the eggs was much lower than for the nymphs, in this case, does not obscure the aforementioned fundamental deduction.

The data for the development of the four larval instars and the pupal stage of this mosquito taken as a unit, when compared to the

data for the component stages, offer no reason whatever to necessitate consideration of the several stages of this species separately in a study of this kind, even though there is a shift in the optimal temperature from one stage to the next. For other species of insects, as Chapman (1931) suggested, it might be necessary to confine such a study to a single stage. This example may be taken as representative of a single basic type, but the results do not preclude data to the contrary concerning species whose ontogenetic form relationships are fundamentally different.

The several graphs of figure 1, presenting the developmental curves of the egg stage, the first, second, third, and fourth instars, and the pupal stage, may be used to test these several considerations. From an examination of these curves and Table I it can be seen that the differences in the time-temperature developmental relationships from one stage to another are largely of the quantitative order rather than the qualitative. There is a decided drop in the optimal temperature as development progresses from the embryonic to the pre-imaginal phases. This difference is from about 33.3° C. for embryonic development to about 30.3° C. for the fourth-instar and pupal stages—a difference of 3.0° C. (5.4° F.). The shift is largely consistent, always proceeding in the same direction.

The following are two possible explanations of this phenomenon:

1. The decrease in the optimal temperature is correlated with the same factors which contribute to the developmental accelerations resulting from variable temperatures as opposed to constant. As greater and greater time is spent at a given high temperature the developmental efficiency of that temperature is more and more reduced. That is, the initial rates of the metabolic processes are not maintained. This alternative assumes that there is no fundamental difference in the true optimum of one stage as compared with another, providing all previous development has been spent at the same low temperature. This explanation is supported by the fact that development was somewhat faster for those lots of larvae that, under variable temperatures, experienced a shift in temperature every six hours as opposed to those that experienced shifts every twelve hours (see Table IV). The rate of accumulation of thermal units (hour-degrees) was the same in each case. It is further supported by the fact that on several occasions individuals which had undergone their total larval development at about 35.0° to 35.5° C. died in the pupal stage at that temperature, whereas individuals that had been reared at 25.0° C. until pupation completed the pupal stage at the high temperature of 35.0 to 35.5° C. This exhibits the accumulative injurious action of high temperature.

2. There is also some deductive reasoning which suggests that there may also be a difference in the true optimum of different stages. As the developing form grows in size and becomes more complex in its metabolic demands, the problem of supplying the tissues with the necessary constituents for anabolic processes and of the removal of waste products of metabolism becomes increasingly more acute. Though the mechanisms concerned are enormously changed and made more efficient, it is possible that they do not completely keep pace with the added burden of supplying a rapidly increasing volume of living tissue,

and of continually readjusting the balance of a vigorous metabolism. Hence, the relative balance between anabolic and katobolic processes is changed so that the originally optimal temperature no longer supports the greatest net product of growth and development. No experimental results were obtained to support this view.

The writer is of the opinion, however, that both the aforementioned explanations are operative and that neither is correct to the complete exclusion of the other.

The several stages vary considerably in the actual time required in completion. Obviously, a stage that requires a much greater total growth as well as basic tissue transformation (such as the fourth instar) will require a longer time for its completion if the same basic rate of growth and development, in terms of unit mass of material added or transformed, is maintained. Without establishing the quantity of such changes within each stage, it is impossible to compare the true rates of growth and development of the different stages. Nevertheless, it is of considerable interest to see if the same fundamental type of curve applies to the rates of development for all stages. In this case and in all the work herein reported, the rate of development is not a true rate, but is based on the portion of the total development of a given stage (not quantitatively comparable to that of another stage) that is completed in one hour. The scale used in plotting the rate of development is, therefore, of no importance. As previously stated, by changing the scale it can be shown that the same fundamental velocity curve applies to all stages. However, the velocities are plotted on the same scale, so as to show that the total quantity of changes taking place at one stage may require decidedly greater amounts of time than that at another. It is seen that those stages which undergo the greatest and most profound growth and transformations are the ones that require the longest time. These are the egg stage, fourth instar, and pupal stages. The fourth instar, involving by far the greatest increase in mass as well as marked qualitative changes, required approximately twice the time of the first, second, and third instars. It also required much more time than either the egg or pupal stages.

Crowell (1940) stated that, under optimal temperature, a total of about 23 days are required for the larval and pupal development of this species. The present data have established that as short a period as 7.3 days may be sufficient to complete this development. Crowell was writing from experience with rearing larvae under laboratory conditions at a temperature of about 24° C. (75° F.). He reared 300-500 larvae in a 20" x 12" flat, enameled rearing pan, and there is no question but that food was the limiting factor rather than temperature. Also, considering 24° C. as optimum was a mistake so far as developmental velocity is concerned. However, that probably is a good culture room temperature, considering the longevity of adult life, mating, total oviposition per female, vigor, mortality during development, etc. The time required at 24° C. in these experiments was 12 days rather than 23. His results were with a Florida stock which had been in captivity several years, whereas these data are largely from a Wilson Dam, Alabama, stock which had been in captivity only a short while. It is felt that this is also a partial explanation of the greatly different figures.

Viewing these data, it is obvious that under the most favorable conditions in nature the entire larval and pupal gamut could be completed in one week, and ordinarily would require from one to three weeks, depending upon the temperature and nutrition factors as the most commonly prevailing limiting conditions. In determining the interim between larvicidal applications, it is obvious that the speed with which the species develops under the particular conditions should be considered. Temperature is of primary importance where food is abundant, but it is probable that the limiting factor will vary somewhat from one breeding condition to another—even from one very small microhabitat to another within a general breeding area.

Another way in which these data may be utilized in practical work is that it should now be much easier to determine the temperature at which purely physiological and medical experiments with this insect should be conducted.

#### THE THRESHOLD, "OPTIMAL SURVIVAL," AND HIGH AND LOW LETHAL TEMPERATURES

The threshold of development of *Anopheles quadrimaculatus* has not been accurately determined. Criteria of development at such low temperatures are not very dependable. The threshold is certainly below the highest low-temperature death point ( $11^{\circ}$  C.). Definite development was observed at  $8.5^{\circ}$  C., but this was not measurable, for the first stage was never completed. At this and lower temperatures the larvae spend much of the time lying inactive on the bottom. However, they can be made to come to the top and perform feeding movements. At  $6^{\circ}$  C. no observable development occurred. Hence, about  $7^{\circ}$  C. may be taken as at least an approximate threshold.

The differences in survival under variable and constant temperature conditions were found to be insignificant in these experiments when medial temperatures were employed. A comparison of survival under such conditions is presented in Table II. Average survival to maturity under constant temperature conditions was 83.3 per cent, while under two types of comparable variable temperature conditions the survival was 76.6 and 78.9 per cent, respectively. These differences may in large part be accounted for by the mechanical injury and entanglement in fungus mycelia, due to moving the larvae from one unit of the temperature cabinet to another. With regard to the constant temperature data, there seems to have been a peak of survival, 92.0 per cent, at about  $29.6^{\circ}$  C., which is also near the temperature of highest velocity of development. This may mean only that there was a shorter period of exposure to the ever-present danger of entanglement in the fungus mycelia.

For temperatures above the optimum or those definitely below the straight-line portion of the velocity curve there is a sharp reduction in survival as the temperature is increased in the former case or decreased in the latter. Constant temperatures of  $10^{\circ}$  C. were lethal to all larvae, and it is probable that  $11^{\circ}$  C. also would be, for at  $12.1^{\circ}$  only 1.7 per cent completed development and attempted emergence. Since these did not successfully emerge, even this temperature may be considered too low for the completion of development. At  $15.7^{\circ}$  C. only 20.0 per

cent developed to adults. Above the optimum, at 34.4° C., only 44.0 per cent completed development, and at 35.0° C. no emergence occurred. Considering other data not herein tabulated, a temperature of 35.0° C. permitted about 50 per cent to pupate, but these died in that stage. At a temperature of 36.1° C. all died in the fourth instar or earlier. At 38.5° C. all died early in the first instar—after 7 hours, 20 per cent were alive; after 29 hours, only 12 per cent; and after 31 hours, none was alive.

TABLE II

AVERAGE SURVIVAL OF *Anopheles quadrimaculatus* TO EMERGENCE UNDER CONSTANT TEMPERATURE AND TWO TYPES OF VARIABLE TEMPERATURE CONDITIONS\*

Constant Temperature		Two 6-Hour Periods Daily at Both High and Low Temperatures		One 12-Hour Period Daily at Both High and Low Temperatures	
Temperature	Percentage Survival	Mean Temperature	Percentage Survival	Mean Temperature	Percentage Survival
10 0	0 0†				
12 1	1 7†				
15 7	20 0†				
19 0	80 0	20 0	72 0	20 0	88 0
21.8	76 0	23 0	68 0	23 0	56 0
24 5	84 0	23 2	72 0	23 2	76 0
27 1	88 0	24 4	88 0	24 4	84 0
29 6	92 0	24 8	64 0	24 8	68 0
32 4	80 0	25 7	84 0	25 7	88 0
34 4	44 0†	27 0	88 0	27 0	92 0
35 0	0 0†				
Averages	83.3		76.6		78.9

\* All temperatures are in degrees Centigrade.

† Omitted from the comparative averages.

There seems to be little question that the injurious effects of high temperatures are accumulative. An occasional pupa reared previously at 25° C. was able to emerge at 35.5° C., whereas at 35.0° C., as previously stated, none emerged if reared throughout its development at that temperature. At temperatures of 36 and 37° C. even those pre-reared at 25° C. were unable to complete pupation.

### COMPARISON OF CONSTANT AND VARIABLE TEMPERATURES

Both Cook (1927) and Peairs (1927) published data which show that the highest rate of acceleration in insect development under variable temperature conditions is obtained if the continuous daily exposure at the high temperature is a short period—6 to 8 hours. Cook found that the highest acceleration over that at constant temperatures was obtained by decreasing the daily exposure at the high temperature as that high temperature is increased. The data of figure 2 and Tables III and IV,

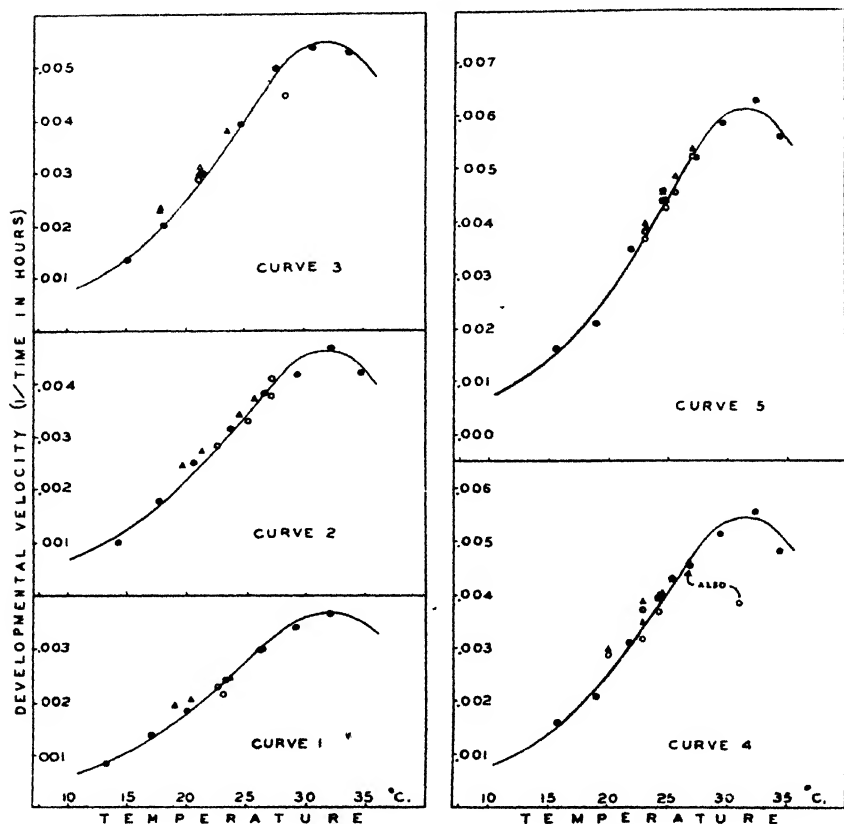


FIGURE 2. Curves showing the relation of temperature to the velocity of development, from newly-hatched larvae to adults, of *Anopheles quadrimaculatus* under constant and several types of variable temperatures. Curves are reciprocals of the catenary,  $t = (m/2) (a^T + a^{-T})$ , where  $t$  = time,  $m$  is the time required at the optimum,  $a$  is a constant, and  $T$  is the temperature in degrees Centigrade above or below the optimum—based on average first-half emergence. All curves are for the "Wilson Dam, Alabama strain" except Curve 1 which is for the "Boyd strain." Black circles represent constant temperatures. The actual curves are calculated on the basis of these constant temperature data only (black circles). Triangles represent exposures of 9 or less continuous hours daily at the high temperature, the remainder being spent at the low. White circles represent exposures of 12 or more continuous hours daily at the high temperature, the remainder being spent at the low. The complete experimental data are not numerically presented in this paper. The explanatory data for this figure follow:

Curve	Data for Establishment of Curve			Daily Exposure to High Temperatures	
	Optimal Temp.	$m$	$a$	Triangles	White Circles
1	31.8° C.	274 hrs.	1.120	One 9 hr. Period	One 15 hr. Period
2	31.5° C.	220 hrs.	1.125	One 9 hr. Period	One 15 hr. Period
3	31.3° C.	184 hrs.	1.130	One 6 hr. Period	One 18 hr. Period
4	31.4° C.	184 hrs.	1.130	Two 6 hr. Periods	One 12 hr. Period
5	31.3° C.	161 hrs.	1.140	Two 6 hr. Periods	One 12 hr. Period

TABLE III

THE RELATION OF THE VELOCITY OF DEVELOPMENT OF *Anopheles quadrimaculatus* TO THE PERIOD OF EXPOSURE AT THE HIGH TEMPERATURE AND TO THE LOW TEMPERATURE EMPLOYED IN VARIABLE TEMPERATURES EXPERIMENTS WITH COMPARISONS TO CONSTANT TEMPERATURE DATA\*

Constant temperature condition (values taken from the appropriate curves for the constant).	To Compare with "A"	Temperature	20.2	23.2	24.9	27.0		
		Velocity	.00239	.00335	.00401	.00493		
	To Compare with "B"	Temperature	22.8	24.8	25.9	27.0		
		Velocity	.00290	.00372	.00434	.00493		
VARIABLE CONDITION A	Continuous periods of 6 to 9 hours daily at the high temperature—remainder at the low.	Low Temperature	Average	15.0	19.0	23.0	24.5	
			Range	12.0-16.9	17.9-20.4	21.3-23.5	None	
	High Temperature	Range	24.4-31.6	27.0-30.8	27.0-29.3	29.5-29.7		
	Average Temperature per Hour of Exposure	Average	20.2	23.2	24.9	27.0		
		Range	15.3-23.1	21.1-26.8	23.3-25.7	26.9-27.1		
	Velocity	.00271	.00345	.00418	.00498			
	Percent Change from Velocity at the comparable constant temperature		+13.4	+3.0	+4.2	+1.0		
			(Average = +5.4)					
	VARIABLE CONDITION B	Continuous periods of 12 to 18 hours daily at the high temperature—remainder at the low.	Low Temperature	Average	15.0	19.0	23.0	24.5
				Range	12.0-16.9	18.0-20.4	21.3-23.4	None
High Temperature		Range	24.4-30.7	27.0-30.7	27.0-30.6	29.5-29.7		
Average Temperature per Hour of Exposure		Average	22.8	24.8	25.9	27.0		
		Range	20.0-25.6	22.9-26.9	24.3-28.3	26.9-27.1		
Velocity		.00306	.00362	.00424	.00486			
Percent Change from Velocity at the comparable constant temperature		+5.5	-2.7	-2.3	-1.4			
		(Average = -0.8)						

\*All temperatures are in degrees Centigrade, and all data are for average first-half emergence and are based upon development from eclosion to emergence. Most of the values given are based upon rearings of from 5 to 10 lots of larvae (depending upon the value considered), but the data at the average temperature of 27.0° per hour of exposure are based upon only 2 lots for each condition. The initial number of larvae used in each lot was 25. There is no way for the reader to check the derivation of the temperatures and/or other values given, since the average low temperatures and average temperatures per hour of exposure are not derived by simply averaging the values showing the range. Temperatures were very accurately recorded twice daily throughout the development of each lot of larvae, and low temperature averages were calculated for each lot. These low temperature averages for all lots in a given condition were then averaged to give the average low temperature shown in the table. Arrival at the respective average temperatures per hour of exposure was a much more involved procedure. The time exposed daily (in hours) to a given high temperature for each lot was multiplied by that high temperature (in degrees). The same was done for the low temperature employed with the same lot. These two products were then added and the sum divided by 24 to give the true average temperature per hour of exposure for the development of the lot. These values for all lots under a given condition were then averaged to give the average, average temperature per hour of exposure shown in this table.



TABLE IV

A COMPARISON OF THE METABOLIC POWER OF TWO VARIABLE TEMPERATURE CONDITIONS HAVING THE SAME SPEED OF ACCUMULATION OF THERMAL UNITS, AND COMPARISONS WITH CONSTANT TEMPERATURE CONDITIONS\*

Average Temperatures (Low and High Temperatures in Parentheses)	Developmental Velocity at the Comparable Constant Temperature†	Two 6-Hour Periods at the High and Low Temperatures		One 12-Hour Period at the High and Low Temperatures	
		Developmental Velocity	Percentage Change Relative to Velocity of the Constant	Developmental Velocity	Percentage Change Relative to Velocity of the Constant
20 0 (15 7 & 24 4)	00250	00295	+ 18 0	00288	+ 15 2
22 9 (18 8 & 27 0)	00336	00347	+ 3 3	00314	- 6 5
23 1‡ (15 7 & 32 5)	00372	00394	+ 5 9	00380	+ 2 2
23 1‡ (15 7 & 32 5)	00339	00388	+ 14 5	00373	+ 10 0
23 2 (19 1 & 27 3)	00373	00385	+ 3 2	00364	2 4
23 3 (12 0 & 34 5)	00350	lethal	.	lethal	.
Average	.	.	+ 9 0	.	+ 3 7
24 3 (21 7 & 27 0)	00381	00398	+ 4 5	00369	3 1
24 6 (21 9 & 27 3)	00430	00452	+ 5 1	00439	+ 2 1
24 7‡ (18 8 & 32 4)	00390	00408	+ 4 6	00394	+ 1 0
24 8‡ (19 1 & 32 5)	00440	00439	0 2	00424	3 6
Average	.	.	+ 3 5	.	0 9
25 6 (21 7 & 29 5)	00421	00431	+ 2 4	00433	+ 2 9
25 7 (21 8 & 29 7)	00470	00483	+ 2 8	00452	- 3 8
26 9 (24 3 & 29 5)	00465	00463	- 0 4	00450	- 3 2
27 1 (24 6 & 29 7)	00521	00532	+ 2 1	00521	0 0
Average	.....	...	+ 1 7	...	1 0
Averages	.	.	+ 5 1	.	+ 0 8

\* All temperatures are in degrees Centigrade, and all data are for average first-half emergence and are based upon development from eclosion to emergence.

† Developmental velocities for the constant temperatures are taken from the appropriate velocity curves.

‡ Value is the result of reducing the post-optimal high temperature to the developmentally equivalent pre-optimal temperature and averaging the corrected high temperature with the low temperature.

corroborate the work of these authors. Table III shows the relation between the temperature of the low exposure and the development, under variable conditions. With daily continuous exposures of 9 hours or less at the high temperature, and when the low temperature was near 15° C. there was an acceleration of 13.4 per cent, and with low temperatures of 19 and 23° C. the acceleration over the constant was 3.0 and 4.2 per cent, respectively. When the low temperature was raised to 24.5° C. there was an acceleration of only 1.0 per cent. These figures give an average of 5.4 per cent acceleration for all low temperature exposures under this condition.

On the other hand, daily continuous exposures of either 12, 15, or 18 hours at the high temperature gave some velocities that were above and some that were below the velocities at the numerically comparable constant temperatures. Considering the data of this type of temperature variation as a whole, there would seem to be neither a retardation nor an acceleration. The average change for all temperatures, as shown in Table III, was -0.2 per cent compared to the constant. This is a negligible figure. However, Table III reveals that when the low temperature was about 15° C. there was an acceleration of 5.5 per cent. When the low temperature was about 19, 23, and 24.5° C. there was a retardation of 2.7, 2.3, and 1.4 per cent respectively, compared to the constant.

The question arises as to whether these figures representing retardation are significant. They are derived from the average first-half emergence of 14 lots of 25 larvae each for both the constant and variable temperature conditions. Of the 14 pairs of lots, 10 of the variable lots showed a retardation and 4 an acceleration. The figures for acceleration were also generally less than those for retardation. It would seem, therefore, that disregarding the group exposed to 15°, there was a slight retardation under the conditions of these experiments. It is probable that there was some slight shock or disturbance accompanying the sudden shifts in temperature.

The data of Table IV confirm the aforementioned statements and are a more detailed elucidation of a part of the data of Table III.

Returning to figure 2, which is a graphic presentation of a much greater number of results than it has been possible to present in tabulated form, some explanations and discussion are appropriate. As stated in the legend to figure 2, the curves presented are plotted on the basis of the constant temperature data only. The black circles represent all the constant temperature data obtained during the course of this study. It may be noted that, on the whole, there is a very close conformity between the formulated curve and the black circles, representing the empirical data, in every case. A total of 38 such points are established, involving data obtained at temperatures representative of the entire biokinetic range for this species, and distributed fairly equally among the five major experimental lots of larvae.

It may be observed that there is some considerable difference in the reaction presented by one curve as compared to another. Two genetical aspects are perhaps partial explanations.

The "Boyd strain," presented in curve 1, would not necessarily be expected to react to temperatures in exactly the same way as the

"Wilson Dam, Alabama strain." Also, different batches of eggs, probably in each case deposited by a few individuals, may have possessed inherent differences in temperature reaction. Furthermore, it is certain that in the case of curves 1 and 2, the method of feeding had not been sufficiently perfected so as to completely eliminate the food factor as a partially limiting condition. In the case of curve 5, the development of the entire lot was unusually fast. During much of this period there was present, unfortunately, a considerable amount of free ammonia in the rearing chamber. It is possible that this condition may have stimulated a more rapid rate of development.

In spite of the apparent differences in the reactions of the several major lots of larvae, as represented by the data of curves 1 to 5, inclusive, there remains one principal fact. This fact is that those larvae exposed to high temperatures for continuous periods of 6 or 9 hours daily developed faster than those exposed for continuous periods of 12, 15 or 18 hours daily or those exposed to constant temperatures. An examination of the position of the triangles for each example will show that all are either on the respective line representing the constant temperature data or above it, and in many cases well above. A total of 25 such points are established. On the other hand, the white circles are situated both above, below, and on the respective lines representing the constant temperature data. It should also be noted that in those cases where there are paired data for the two variable temperature conditions (see curves 4 and 5), the white circles in every case except one occupy positions representing a slower rate of development than the triangles. In the case of the one exception, the two have essentially the same position. A total of 22 white circles are established. It may be concluded, therefore, that the more extensive data presented in figure 2, as compared to those presented in Tables III and IV, are in complete agreement with the tabulated results.

It is seen from the results of Table III and figure 2 that there were both retarding and accelerating effects of sizeable daily shifts in temperature. It is highly probable that under natural variations a retardation would not occur. Only when the daily exposure at the low temperature was a long period and that at the high temperature a short one did the accelerative phase completely over-balance the inhibitive in these experiments involving sudden and large changes in temperature.

These results are in agreement with the previously discussed statements of Blackman (1905), to the effect that the maximum rate of metabolism at a high temperature is maintained only at the beginning and that the rate of decrease in this rate with time is at first fast but becomes progressively slower. Under a long exposure at the low temperature, the injurious state that has resulted from exposure to the high temperature is corrected and the insect is again in a physiological condition to sustain the maximum rate of initial metabolism when returned to the high temperature. Too short an exposure to the low temperature would not allow the complete rest or correction (whatever is the true nature of the change that occurs), and the maximum rate of metabolism could not be accomplished when the insects are returned to the high temperature.

It seems possible that the processes associated with supply of assimilable substances, utilization, and disposal of waste products in the complicated developmental process are not equally affected by temperature changes. Therefore, when there are no accumulated deleterious waste products present, and when the reserve of nutritive substances and necessary conditions are at an optimum, the highest possible metabolism can take place at a given temperature. If that temperature is relatively high, for example, the processes involved in waste disposal may not occur as fast as those responsible for growth, development, and the production of those waste products. Or again, it may be the processes of supply and translocation that are unable to keep pace. In any event, the rate of development is forced to come to a balance with the total complex of processes.

The present data may be further discussed with respect to Blackman's concepts. As previously stated, there was a decided increase in the rate of development above the rate at the comparable constant temperatures only when the period of continuous exposure at the high temperature was 6 or 9 hours. In this group there was little change (1.0 per cent) relative to the constant if the low temperature of the variable was at about 24.5° C. This result is in conformity with the statement of Blackman that below 25° C. (for carbon assimilation of the leaves of cherry laurel) there is no further falling off of the initial rate of metabolism. Hence it is presumed that if, down to 25° C., a falling off occurs, there could be no correction of the accumulated deleterious condition by exposure to low temperatures of 25° C. or above. Some of the low temperatures were as low as 24° C. It is also certain that the figure of 25° C. would not apply rigidly to another species of organism or other type of metabolic process.

When the temperature of the low exposure was reduced to 23° C. or to 19° C. for the same rhythm of variation, there was an increase in velocity of 4.2 and 3.0 per cent, respectively, above that under the constant. These differences are not large, but, when compared to the retardations in velocity (see lots exposed 12, 15, or 18 hours at the high temperature, in Table III) of 2.3 and 2.7 per cent, respectively, their magnitudes seem greater. The corrective power of these medial temperatures is not very great. When the temperature of the low exposure for this group was about 15° C. there was a great increase in the velocity of development over that under the comparable constant temperature. The increase was 13.4 per cent in this case, and compares with increases that have been reported by Peairs (1927), Shelford (1929), and Headlee (1941) under certain conditions for other insects. Headlee (1941) also obtained the greatest acceleration over the constant for the development of *Aedes aegypti* L. when the low temperature was very low (10° C.).

For the variable groups that were held 12 hours or longer continuously at the high temperature there are two factors visibly affecting the sequence of the change in velocity as the low temperature is decreased. The injurious effect of shock is increased at the same time that the accelerative phase of the variable is made more functionable. Under these conditions, however, the injurious effect continued to

dominate. Only when the low temperature was about 15° C. was there an appreciable acceleration (5.5 per cent) over the velocity at the constant.

Temperatures near 15° C., therefore, have a high corrective power. The evidence indicates that there is a rather rapid increase in the corrective or stimulating power of a low temperature as that low temperature approaches 17° C. or less for this species.

The possibility that the difference in the metabolic power of a degree (depending upon where in the biokinetic scale that degree is taken) may in part account for the observed differences in the metabolic power of constant and variable temperatures, needed experimental consideration. From the procedure used by Headlee (1941), it is presumed by the writer that Headlee had this approach in mind. However, he did not state the objective in these terms at all, but rather in terms of explaining the variation of the metabolic power of the variable and the constant as being due to differences in the rate of accumulating the thermal units. (These results have been discussed in an earlier section, p. 8.)

The validity of the previously mentioned concept can now be considered. In Table IV there are data on the velocity of the constant and of two classes of variable temperature groups. Curves 4 and 5, figure 2, present these data graphically. Any group of three in the table is made up of strictly comparable results, but comparisons otherwise are not so valid. In both variable temperature groups the total exposure was for 12 hours daily at both the high and low temperatures, and the specific temperatures involved were identical. Therefore, the rate of accumulating thermal units was identical, and, more important, the thermal energy in degrees was taken from exactly the same position in the biokinetic scale. This latter statement is not true for the constant, however. Comparing these two variable groups, it is seen that of every pair but one, the group shifted twice daily had velocities distinctly above the group shifted only once daily, the average velocity difference between the two groups being about 4.3 per cent. The variation was mostly about 3 per cent, with a maximum of 10 per cent. In the one case, the group shifted twice daily developed 0.5 per cent slower than the group shifted but once.

Nearly all the velocities in the group shifted twice daily are higher, while half of those shifted only once daily are lower than the velocities at the comparable constant temperatures. In these considerations it has not been necessary to consider the actual temperatures involved. As before, the greater increases over the constant are to be found where the temperature of the low exposure is very low. The only two large positive changes for the once-shifted group had exposures to low temperatures of about 16° C. Likewise, the two larger positive changes for the twice-shifted group had exposures to low temperatures of about 16° C.

The fact that there was essentially no net change in velocity from that at the constant for the once-shifted group signifies that when the continuous exposure at the high temperature was 12 hours the inhibitive and accelerative phases of the effects of variable temperatures nearly balanced. When shifted twice daily the insects were able to sustain

two periods daily of maximal initial developmental rate instead of one. As to why there would not have been two injurious shocks daily to off-set these is not answerable to any degree of finality. However, it may be that when shifted more often the changes become less of a shock to the developing larvae, due to a greater degree of acclimatization.

These data are in agreement with the concept of Blackman that the maximal initial rate of metabolism at a given high temperature falls off with time. On the other hand, the differences in the metabolic power of two variable temperature groups, as here shown, cannot be attributed to variations in the position in the biokinetic scale of the temperatures to which they were exposed. The known variation in metabolic power of temperature, according to its source, is not the explanation of the differences in the metabolic power of the variable and the constant. The tremendous variation between the variable and the constant, reported by some authors, *e. g.* Cook (1927) and Parker (1930), would seem to have precluded such an explanation.

### SUMMARY

The reciprocal of the catenary curve,  $t = (m/2) (a^T + a^{-T})$ , seems to be the most adequate and adaptable method yet advanced for expressing the relation of temperature to the velocity of insect development. This formula is derived from two simple exponential functions, one representing an accelerative and the other an inhibitive effect of increased temperature.

The reaction of development of the malarial mosquito, *Anopheles quadrimaculatus* Say, has the same general form for the total period of development as for any individual component stage. There is, however, a significant shift in the optimal temperature from about 33.3 to 30.3° C. as development progresses from the embryonic to the pre-imaginal phases. The time-temperature relation in the development of this species conforms remarkably well to the catenary formula. The optimal developmental temperature is at about 31° C., and the time required to complete development from newly-hatched larvae to adults may vary from as high as 1572 hours (65.5 days) at 12.1° C. to about 176 hours (7.3 days) at the optimum. The shortest time required to complete each stage is near 30 hours (this figure is about 55 hours for the fourth instar).

The threshold of development for this mosquito is about 7° C. The lowest generally lethal high temperature is about 35° C., and the highest generally lethal low temperature is about 11° C.

High temperatures have an accumulative injurious effect; a pupa, pre-reared at about 35.0° C. is very likely to die at that temperature, whereas one pre-reared at a lower temperature and then shifted to 35.0° C. may emerge. The concept that lethal high temperatures are associated with the coagulation of protoplasm seems to be untenable; death at these temperatures may be similar to starvation at lower temperatures.

The metabolic power of variable temperatures is greater, generally, than that of constant temperatures, this difference being probably attributable to an inherent inability of the insect to maintain the initial

rate of metabolism at high temperatures. The speed of accumulating thermal units or the specific source of the thermal energy, is not the explanation. The degree of acceleration of variable temperatures is greatly affected by the exact nature of the variation. Exposure to low temperatures of 17° C. or slightly lower are far more powerful in promoting an increased metabolic rate than are exposures to higher low temperatures. The basic explanation is probably that different important phases of metabolism respond to temperature changes differentially.

Information put forward in this paper should be of value in determining the interim of time between larvicidal applications in anti-malaria operations. It should also now be much easier to determine the temperature at which purely physiological and medical experiments with this insect should be conducted.

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## NEW SCARABAEIDAE FROM UNITED STATES (Coleoptera)

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The type specimens of the scarab beetles described herein will be retained temporarily in the author's collection. At some future date, the holotypes and allotypes will be placed in the United States National Museum.

### ***Ataenius linelli* n. sp.**

*Holotype*.—Length 4.3 mm., width 1.9 mm. Oblong, moderately elongate, convex, shining, piceous brown shading to dark castaneous over head and sides of thorax; underparts of thorax still lighter; legs castaneous; antennae and trophi pale. Clypeus broadly emarginate, a small denticle each side, transversely rugose anteriorly; front moderately convex, front and sides sparsely very finely punctate; punctures of vertex fewer and only slightly larger. Pronotum strongly convex, about one-third wider than long; marginal groove strong and entire, marginal setae fine and inconspicuous; surface with mixed punctures, sparse coarse punctures unevenly but generally distributed, finer in front and coarser and closer at the sides, with interspersed very fine evenly distributed punctures throughout. Elytra convex, seven-tenths longer than wide; striae deep, moderately closely crenately punctate; intervals convex, minutely punctulate. Mesosternum shagreened. Metasternum roughened anteriorly at sides, shining at middle, with minute punctures throughout, a small group of slightly larger fine punctures on each side of median groove. Abdominal sternites shining, impunctate at middle, a transverse row of three or four well separated coarse setigerous punctures outward at the sides, the setae rather long and fine, and with a group of moderately coarse punctures at extreme edges; transverse basal row of pits well defined. Middle and posterior femora smooth, shining, with a row of three or four coarse setigerous punctures at knee; posterior marginal groove well defined one half the distance from knee, and indefinitely continued over other half; posterior tibia with accessory spinule. Sex not determined.

The eleven specimens of the typical series vary in length from 3.9 to 4.6 mm., in width from 1.8 to 2.0 mm. The clypeal denticles vary from mere angulations of the narrowly reflexed margin to low triangular teeth.

Holotype from Miami, Florida, May 1919. Nine paratypes with same data; one Miami, September, 1923. Paratypes in collections of Oregon State College, U. S. National Museum, and Mark Robinson.

<sup>1</sup>Technical Contribution No. 97 from the South Carolina Experiment Station, Clemson, South Carolina.

*Ataenius linelli* keys to *laeviventris* in Horn's monograph but is much nearer *schwarzi* (Linell) which it resembles closely in general shape, color, and other characters. However, *linelli* differs from *schwarzi* in that the clypeal rugosity is less strongly developed, the vertex of the head is finely punctate, the coarse punctures of the thorax are less coarse and more widely distributed, and the marginal groove of the posterior femur extends half its length.

***Ataenius saxatilis* n. sp.**

*Holotype Male*.—Length 4.1 mm., width 1.8 mm. Convex, piceous, strongly shining; sides of pronotum, edge of clypeus, underparts of thorax, and legs dark castaneous; trophi and antennae pale. Clypeus broadly emarginate, each side evenly rounded without trace of denticle or angulation; feebly wrinkled anteriorly, finely punctate, minutely punctate medially, vertex with a rather wide band of moderately coarse punctures separated by one or two diameters. Pronotum about one and one-half times as wide as long, without marginal setae, marginal groove fine and entire, anterior angles obtuse, posterior angles broadly rounded, highly polished surface with generally distributed sparse irregularly spaced moderately coarse punctures separated on disc by one to four or five diameters, slightly coarser and closer at sides, and with interspersed similarly distributed extremely fine, almost microscopic, punctures throughout. Elytra about one and two-thirds as long as wide, sides not quite parallel, widest slightly beyond middle; striae fine, not deep, finely crenately quite closely punctured; intervals almost flat, the polished surface with microscopic punctures; lateral margin strongly convex. Pygidium convex, smooth, polished, with a very few scattered moderate punctures and interspersed microscopic punctures. Mesosternum shagreened and with fine short decumbent hairs. Metasternum, abdomen, and legs virtually impunctate. Two terminal abdominal segments shortened, penultimate about two-thirds the length of the preceding, terminal two-thirds the length of the penultimate. Usual basal row of pits on abdominal sternites practically invisible except under high magnification. Posterior femur without marginal groove; posterior tibia without accessory spinule.

*Allotype Female*.—Length 4.3 mm., width 1.9 mm. Penultimate segment not shortened. Pygidium less convex and not as long. Otherwise as in male.

The 350 specimens of the typical series vary in length from 3.5 to 4.6 mm., in width from 1.6 to 2.1 mm.

Holotype and allotype taken in copulo, Bogg's Rock, Liberty, South Carolina, July 9, 1940, O. L. Cartwright. Paratypes collected in the following South Carolina localities: Bogg's Rock, Liberty, July 9 to August 19, 1940, June 18 to September 1, 1941, O. Starnes and Cartwright; Forty Acre Rock and Haile Gold Mine (both in Lancaster Co.), Lancaster, and Jefferson, July 20, 1940, Starnes; Bald Rock, 4 miles south of Caesar's Head, July 25, 1940, Cartwright; Table Rock Mt., August 6, 1940, Starnes; Beverly, August 22, 1941, Starnes; and Camp Adger, Pinnacle Mt., August 28, 1941, Starnes. Also Stone Mt.,

Georgia, August 15, 1940, P. W. Fattig (a single specimen with much closer and somewhat coarser thoracic punctuation); Flat Rock, Flat Rock Creek, 7½ miles east of Columbus, Georgia, July 6, 1941, Cartwright; and High Falls, Little River, Buck's Forest, North Carolina, July 22, 1941, Starnes and F. K. Hinnant.

Paratypes in U. S. Nat. Mus.; Field Museum of Natural History, American Museum of Natural History, Museum of Comparative Zoology, Philadelphia Academy of Science, California Academy of Science, various university and private collections.

All specimens of this highly polished, shining, jet black species were collected in the sand washed down to the edges of pockets or islands of soil and vegetation on outcroppings of bare weathered areas of granite or gneiss rock, or in the sand and soil around the lower edges or such areas of rock.

*Ataenius saxatilis* is closely allied to *figurator* Harold, however, it is a more robust species differing in general shape. *A. saxatilis* increases noticeably in width from head to slightly beyond the middle of the elytra, whereas *figurator* is more slender and parallel. In addition the sides of the clypeus are more widely rounded and without even a suspicion of angulation each side of the median emargination in *saxatilis*. In *figurator* the clypeus on each side of the median emargination is more sharply rounded, usually with an evident angulation, frequently with a noticeable denticle.

#### ***Eucanthus lazarus* var. *alutaceus* n. var.**

*Holotype Male*.—Length 12 mm., width 7 mm. Apparently identical with typical *lazarus* (Fab.) in every way except that the head, thorax, and elytra are alutaceous, giving the variety a dull, greasy appearance. Such lustreless specimens are quite noticeable in a series of shining *lazarus*.

*Holotype* collected at Lucedale, Miss., October 4, 1931, by Henry Dietrich. Five paratypes: Lucedale, Miss., April 7, 1932, H. Dietrich; Mobile Co., Ala., June 1, 1936, H. P. Loding; Grand Bay, Ala., August, 1906, H. P. Loding; and Thomasville, Georgia, April 1, 1939, April 24, 1940, P. W. Fattig.

#### ***Phyllophaga yemasseei* n. sp.**

Figures 8, 9

*Holotype Male*.—Length 11 mm., width 5 mm. Elongate oblong, subdepressed, pale brown with head darker, glabrous, moderately shining. Antennae 9-segmented, pale testaceous club subequal to stern. Clypeus rounded with scarcely noticeable shallow emargination, concave with widely and deeply reflexed margin, surface mod-

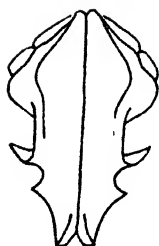
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#### EXPLANATION OF PLATE

Aedeagi. Fig. 1. *Ligyrrus laevicollis* Bates. 2. *Ligyrrus blatchleyi* Cartwright. 3. *Aphonus variolosus* (Leconte). 4. *Aphonus tridentatus* (Say). 5. *Aphonus brevicurvis* Cartwright. 6. *Aphonus castaneus* (Melsheimer). 7. *Aphonus densicauda* Casey. 8, 9. *Phyllophaga yemasseei* Cartwright. 10. *Phyllophaga forsteri* (Burmeister). 11. *Phyllophaga tecta* Cartwright.



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11



erately coarsely, not closely punctate; suture sinuate, unevenly impressed, the sides much more deeply than the slightly impressed median angle. Head somewhat flattened; punctures similar but a little closer than on clypeus, separated by about one diameter or less. Pronotum less than twice as wide as long; sides crenate, widest slightly before the middle, arcuate to obtuse anterior angles, sinuate to right angled posterior angles; punctures about same size as on head but irregularly placed, separated by from one or less to as much as four diameters. Elytra more evenly, more deeply, and somewhat more finely punctate; only sutural costae distinct, others very faint. Mesosternum with very sparse punctures bearing fine hair. Abdomen finely sparsely punctate, the punctures with very short scarcely noticeable hairs; a distinct median longitudinal impression, the terminal and posterior of the penultimate segments slightly roughened with fine transverse granules. Pygidium convex with shallow, indistinct, coarse punctures. Upper spur of hind tibia moderately long, lanceolate, subacute; lower spur obliquely truncate, three-fourths as long as upper; end of tibia excavated. Tooth of claw near base and very small. Aedeagus as in figs. 8 and 9.

Female unknown.

Holotype taken at light, Yemassee, S. C., June 6, 1941, O. L. Cartwright.

*Phyllophaga yemasseei* keys to Horn's group VI, and is very closely allied to *P. debilis* (Lec.) from which it may be separated by the genitalia, by not having the small median denticle on the anterior margin of the terminal abdominal segment as in *debilis*, and by other minor differences.

### ***Phyllophaga tecta* n. sp.**

Figure 11

*Holotype Male*.—Length 19.5 mm., width 10 mm. Elongate oval, shining, glabrous, castaneous. Antennae 10-segmented, rufo-testaceous, club slightly shorter than stem. Clypeus rather deeply emarginate, margin reflexed, surface quite closely punctate, suture sinuate. Head moderately punctate, the punctures slightly coarser than on clypeus and less close, particularly along suture. Pronotum three-fifths as long as wide, widest at middle, sides convergent anteriorly, sinuate to right angled posterior angles, margin crenate, surface shining, punctures still coarser and less closely placed, average separation one to two diameters. Sutural costae of elytra moderately strong and rather wide, discal obsolete, submarginal narrow, obsolete over basal third; surface shining, rather finely moderately closely punctate, middle of disc somewhat rugulose. Mesosternum finely punctate, covered with moderately sparse yellowish hair. Abdomen finely punctate, and with short appressed yellowish hair, median area flattened longitudinally, last two segments with a deep cup-like depression, the penultimate segment finely transversely granulate within the cup and noticeably elevated at the sides, terminal segment smooth within the cup. Pygidium rather sparsely finely punctate. Fixed spur of hind tibia strong, acute, and four-fifths as long as upper; upper thin, lanceolate, subacute, and about as long as first segment of

tarsi. Tooth of claw median, long, nearly right angled. Aedeagus as in fig. 11.

*Allotype Female*.—Length 18 mm., width 10 mm. Club of antennae slightly shorter than funicle, abdomen evenly convex, apex of pygidium more acutely rounded, both spurs of hind tibiae thin and lanceolate, otherwise similar to male.

Type and allotype collected at Gainesville, Fla., March 22 and 13, 1925, by T. H. Hubbell. Eighteen paratypes which vary in length from 17.5 mm. to 21 mm.; in width from 9 mm. to 11 mm., one from Bradenton, Fla., 3-8-38, W. Benedict, all others from Gainesville, Fla., March 12 to May 8, various years 1923 to 1929.

Paratypes deposited in collections of University of Kansas, M. W. Sanderson, Philip Luginbill, F. N. Young, and author.

*Phyllophaga tecta* is very close to *P. forsteri* (Burm.) but averages somewhat larger and the genitalia show a constant difference in structure

***Phyllophaga marginalis* var. *insolita* n. var.**

*Holotype Male*.—Length 18 mm., width 8.7 mm. Oblong, rather elongate, subdepressed, feebly shining to subopaque, dark brown, clothed with semi-erect, fine, rather close mixed short to moderately long hair. Antennae 10-segmented, stem subequal to club. Clypeus flat, emarginate; margin narrowly reflexed; surface coarsely, deeply, and closely punctate; suture sinuate, slightly impressed. Head with a narrow smooth area medially across occiput, otherwise punctate as on clypeus, the punctures bearing fine yellowish recurved hairs which are gradually longer toward the sides of the head. Pronotum not quite twice as wide as long, sides crenate, widest slightly back of middle, arcuate to anterior angles, slightly sinuate to posterior angles; surface coarsely, deeply and densely, in some instances almost confluent punctate, the punctures alutaceous within, and each bearing a fine anteriorly placed recurved hair, the length of the hair being from one to two times the diameter of the punctures. Elytral surface finely alutaceous, vaguely rugulose, and with fine, close, rather shallow punctures, each bearing a fine semi-erect hair of variable length; sutural and submarginal costae distinct, discal costae more or less obsolete. Mesosternum closely finely punctate, clothed with fine yellowish hair. Abdomen with moderately close fine punctures bearing fine short appressed hair; broadly depressed medially; penultimate segment with a short, strongly arcuate, finely roughened ridge at middle, the posterior edge shallowly emarginate; terminal segment with a median depression. Pygidium convex, with moderately close shallow medium punctures, and short appressed hair. Fixed spur of hind tibia rather broad, acute, two-thirds length of the upper which is thin lanceolate and acute. Tooth of claw median, strong, slightly recurved. Aedeagus as in typical *marginalis*.

*Allotype Female*.—Length 19.5 mm., width 10 mm. Similar to male in all respects except that the head and thorax seem even more roughly and more frequently confluent punctured; the pubescence of the elytra is slightly longer; the club of the antenna is shorter than

the funicle; the abdomen is convex; and the apex of the pygidium is more acutely rounded and convex. Genitalia as in *marginalis*.

All 17 specimens of the typical series were submitted by Dr. H. P. Loding and all bear the same label—Cheaha Mtn., Talapoosa Co., Ala. VI-7-40, Mus. Exp. Paratypes in collections of H. P. Loding, M. W. Sanderson and writer.

This subspecies may be associated with *marginalis* through its identical genitalia. Externally its appearance is quite distinct, the rough, very coarse, deep, and dense punctures of the thorax, together with the pubescence of the elytra, serve to distinguish it at once.

### ***Ligyris blatchleyi* n. sp.**

#### **Figure 2**

*Holotype Male*.—Length 24 mm., width 13.5 mm. Oblong oval, shining, rufopiceous, under surface and legs only slightly lighter. Head a little less than half as wide as thorax, rugulose except at occiput where the rugulose lines break into moderate punctures; mandibles bidentate; clypeus triangular, somewhat concave, sides narrowly reflexed, apex bidentate, the upturned teeth approximate, acutely rounded, base with a blunt tubercle midway each side of middle; front shallowly impressed. Thorax two-fifths wider than long, sides broadly rounded, anterior angles acute, posterior angles broadly rounded, front margin with median tubercle immediately in front of a shallow oval depression one-fifth width of thorax, punctures moderate and close, separated by one or two diameters in anterior and posterior angles, finer and closer toward apical tubercle, gradually sparser and much finer medially toward base, a small almost smooth area at middle of each side, the anterior depression with transverse wavy rugulosity breaking to moderate punctures posteriorly. Elytra two and one-third times as long as thorax, widest at posterior third, sutural and discal striae well marked, the coarse annular punctures of the striae and of the alternate wider intervals about equal in size and almost as closely placed, becoming slightly larger laterally, finer at the apex and on the first interval, interspersed sparse fine simple punctures throughout, the subapical and humeral umbones otherwise smooth. Prosternal postcoxal process moderately densely hairy, its apex flattened and nude anteriorly. Mesosternum finely closely punctate medially. Metasternum smooth at middle, coarse shallow alutaceous punctures at sides. Abdominal segments with a transverse row of setigerous punctures laterally, virtually impunctate medially, ciliated edge of terminal segment deeply emarginate leaving a wide depressed smooth apical margin at middle. Pygidium twice as wide as long, evenly moderately convex, base and sides scabriculate, middle and apex minutely punctate. Aedeagus as in fig. 2.

*Allotype Female*.—Length 21 mm., width 12 mm. Very similar to male except that the spur of the anterior tibia is much more slender, the tubercles at the base of the clypeus are obsolete, the thoracic punctures are slightly finer, the pygidium is less convex, the pygidial punctures are much more conspicuous, being of moderate size, quite

close, and discernible even in the scabriculate basal part, to somewhat finer and less closely placed over the smooth apical part, and the terminal abdominal segment is not emarginate.

Holotype and allotype collected at Miami, Florida, June 25 and 30, 1933, by Frank N. Young. Fourteen paratypes, 8 males, 4 females, Miami, Fla., June 16, 22, 25, 30, 1933, F. N. Young; Ft. Lauderdale, Fla., May 24, 1928, D. M. Bates; Everglade, Fla., June, 1912, Wm. T. Davis Coll.; Savannah, Ga., June 15, 1937, P. W. Fattig; Charleston, South Carolina, June 7, 1933, J. P. DeVeaux, Jr.; and a pair of specimens reared at Cornell University from larvae collected at Englewood, Fla., by Dr. J. G. Needham.

The typical series varies in length from 21 to 25 mm., in width from 12 to 14 mm. Considerable variation in the size of thoracic punctures is evident in both sexes, being much finer in some specimens than others. Variation is also noticeable in the elevation and distance between the apical teeth and between the basal tubercles of the clypeus. On one somewhat deformed individual the apical teeth appear as a single binodose tooth. The extent of rugulosity within the apical thoracic depression is quite variable but is evident in all specimens.

I am grateful to Prof. J. J. Davis for comparing specimens with the type of Blatchley's *subtropicus* and for the loan of a specimen labeled *laevicollis* Bates from the Blatchley collection. The latter specimen from Everglades, Fla., collected by W. T. Davis, is included among the paratypes of *L. blatchleyi*.

Prof. Davis stated that *L. subtropicus* was darker, conspicuously larger, measuring about 25 mm. long and 14 mm. wide at base of wings (specimens of *L. blatchleyi* are as long!), mandibles bidentate with the outer tooth twice as large as the inner one (those of *blatchleyi* are about equal in size), apical clypeal teeth strongly acute and the notch between the teeth deep and broad and the teeth sharply upturned, tubercles of clypeal suture conspicuous, about  $1\frac{1}{2}$  mm. apart and the flattened area back of thoracic tubercle with sparsely placed fine punctures, similar to the rest of the thorax. Considering the rather wide variation exhibited in the series here considered a single species (*blatchleyi*), it would seem possible that *subtropicus* might be only an extreme variation of the same species; however, since none of the series shows the thoracic depression "with sparsely placed fine punctures similar to the rest of the thorax" and since Prof. Davis stated concerning *subtropicus*, "there is no question in my mind that it is distinct from the species you sent," I am presenting the above description.

I am indebted also to Dr. J. G. Arrow of the British Museum for comparisons of specimens of *blatchleyi* with the type of *L. laevicollis* Bates. In his opinion the species was distinct from *laevicollis* and was probably undescribed. A specimen of *laevicollis* from lower California, also compared by Dr. Arrow with the type, differs from *blatchleyi* in that the posterior half of the thorax except at the extreme sides is almost devoid of punctures, the apical thoracic area is rugulose but is only very slightly flattened instead of depressed, the first interval of elytra is smooth and lacks coarse punctures near the scutellum and along the sutural stria, and the aedeagus is distinctly different as shown in fig. 1.



**Aphonus brevicruris** n. sp.

Figure 5

*Holotype Male*.—Length 13 mm., width 9 mm. Pyriform oval, convex, shining, dark castaneous. Head convex, small, two-fifths as wide as thorax; clypeus shining, short, concave laterally, side margins reflexed, sparsely moderately punctate, reflexed subapical carina indistinctly tridentate, the middle tooth much higher, apical carina acutely rounded; front and sides of head with coarse sharp wavy interlacing rugulosity, the rugulae gradually more widely separated posteriorly, occiput smooth medially with a few scattered moderate punctures. Thorax convex, two-thirds as long as wide; sides evenly weakly arcuate, converging to acute apical angles, posterior angles obtusely rounded, basal lobe distinct but weak; punctures strong and close-set in and back of the anterior angles, gradually finer and less numerous towards middle, sides and base, the punctures being very fine and sparse over the basal lobe; excepting a few punctures at anterior third the median line rather broadly impunctate. Scutellum longer than wide, smooth, feebly concave. Elytra not quite as wide as long, wider than thorax at base; punctures coarse, shallow, umbilicate, the series somewhat more deeply impressed on the disc, and more noticeably annular toward sides, smaller on apical declivity, surface of lateral fourth and apex rugose with punctures more or less confused. Pygidium strongly convex, nearly twice as wide as long, minutely scabriculate throughout, apical beading strong and equal. Posterior legs short and stout, femur three-fifths as wide as long; tibia shorter than femur, its widely flared apex more than half as wide as full length of tibia; tarsi one-fifth longer than the tibia, the basal segment externally drawn out in a long tooth or spur half the length of the second segment.

Aedeagus distinct (fig. 5).

Female unknown.

The unique holotype collected at Austwell, Texas, May 20, 1941, by Woodrow Goodpaster. *Aphonus brevicruris* superficially resembles large dark specimens of *castaneus* (Melsh.) but is easily recognized by the short heavy tibiae. The aedeagus is quite different from those of the other four species previously found in the United States. All are shown in figures 3 to 7.

# OBSERVATIONS ON THE EARLY STAGES AND LIFE HISTORY OF THE GRASS PUNKY, *ATRICHOPOGON LEVIS* (COQUILLETT)<sup>1</sup>

(Diptera: Heleidae)

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AND

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## INTRODUCTION

*Atrichopogon levis* was described by D. W. Coquillett (1901) from a single female specimen collected at Marlboro, Maryland. Malloch (1915) recorded the species as the commonest of its genus (*Ceralopogon*) in Illinois and mentioned additional records for New York and Michigan. He figured also details of the male antennae and genitalia. Johnson (1925) recorded the species from Massachusetts, Rhode Island, and Connecticut. Up to the present time, we have no published information on the early stages or adult habits of the grass punky.

In August, 1941, Miss Dorothy Clum collected two larvae from algae growing on the surface of damp soil. Their structural features quite readily placed them with known larvae of *Atrichopogon*, but structural details likewise clearly separated them from any of the three American species whose immature stages, excluding eggs, were known. Immediate steps were therefore taken to secure an abundance of material for rearing and observation. Both authors carried on detailed observations at Put-in-Bay, located on South Bass Island, in western Lake Erie; additional observations were made by the senior author at Oxford, and by the junior author at Covington, Ohio. The senior author in 1940 had received a single preserved specimen of *Atrichopogon levis* in the third larval instar from Dr. Philip C. Stone but, since the stage had not been described, the specimen remained unidentified until the present work was nearly complete. Upon re-examination it was readily recognized. To Dr. Stone then must go credit for the original discovery of the larva.

The writers wish to express their indebtedness to Dr. O. A. Johannsen for his valuable suggestions and for his aid in identifying the species treated in this paper; to Dr. C. E. Taft for his determinations of algae; and to Dr. C. F. Walker for information concerning the vertebrate fauna of South Bass Island.

## METHODS

Petri dishes and stender dishes were employed to make life history studies in the laboratory. In general, only one individual was kept in a dish so that its development could be accurately followed. The bottom of each dish was lined with four thicknesses of moist towel paper. On this was placed a piece of earth covered with algae and

<sup>1</sup>Contribution from the Franz Theodore Stone Laboratory, Put-in-Bay, Ohio.

having a total surface of about one-half to one square inch, a size which proved to be adequate for the complete development of an individual from egg to adult. The dishes were kept covered except when the material was being studied. Generally they were placed in windows with a northern exposure, or on laboratory tables, out of direct sunlight. Under those circumstances larvae usually remained strictly on the earth in the dish. Occasionally they would move out of sight for a time, only to reappear later on the soil surface.

Early stages fared well under laboratory conditions described above. Mortality was exceedingly low, having been highest in the pupal stage. It was found possible to collect eggs and carry them through to the adult condition in the dishes. Careful observations were made on larval instars and on other details of the life history. Field observations were necessarily limited because of restrictions imposed by the microscopic nature of some of the stages with which we were dealing.

### DESCRIPTIONS OF EARLY STAGES

*Egg* (fig. 1).—Smooth, subshining, black. About 3.6 to 4.2 times longer than greatest width, depending on view. Slightly curved. Length, 0.37 to 0.41 mm.

*Larva* (figs. 2; 4-7).—The larval stage is represented by four instars. Although the instars are described below in logical order, the first three are covered only insofar as their features differ from the fourth or from each other.

The first instar (fig. 4) differs from all others in that the body projections are hardly evident, even setae being poorly developed. As in the second instar, there is only one seta on each of the second thoracic projections. Length, 0.38 to 0.87 mm. Width of head capsule, 0.08 to 0.10 mm.

The second instar (fig. 5) differs from third and fourth instars in the following respects: projections on the first thoracic segment very short; only one seta on each of the second thoracic projections. Differs from fourth instar in that the projections on the eighth abdominal segment are simple. Length, 0.77 to 1.3 mm. Width of head capsule, 0.11 to 0.13 mm.

The third instar (fig. 6) differs from fourth instar in the following respects: projections on the first thoracic segment hardly more than twice as long as their diameter; projections on the eighth abdominal segment simple; second seta on the projections of second thoracic segment only about a third as long as the first. Length, 1.3 to 2.0 mm. Width of head capsule, 0.14 to 0.19 mm.

*Fourth Instar* (figs. 2 and 7).—Head with ventrally directed mouthparts. Four pairs of cephalic hairs distributed as follows: just posterior to the bases of the antennae, on the front between the antennae and the corners of the mouth, low on the cheeks at the level of the eyes, low and posteriorly on the cheeks; the last three pairs form a sort of ring at or just below the middle of the head. Antennae conspicuous, quite rigid, horn-like, on well developed tubercles; composed of two

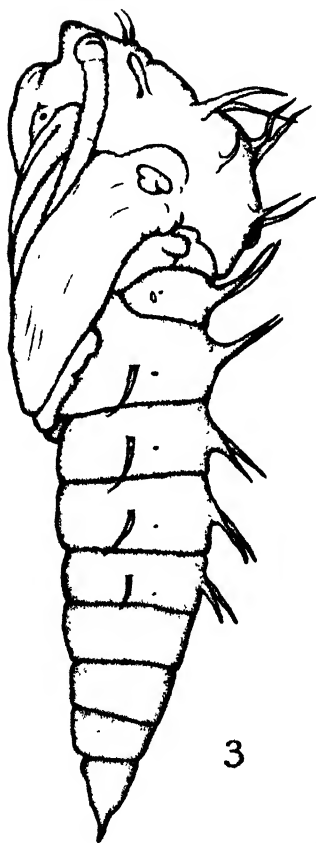
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### EXPLANATION OF PLATE I

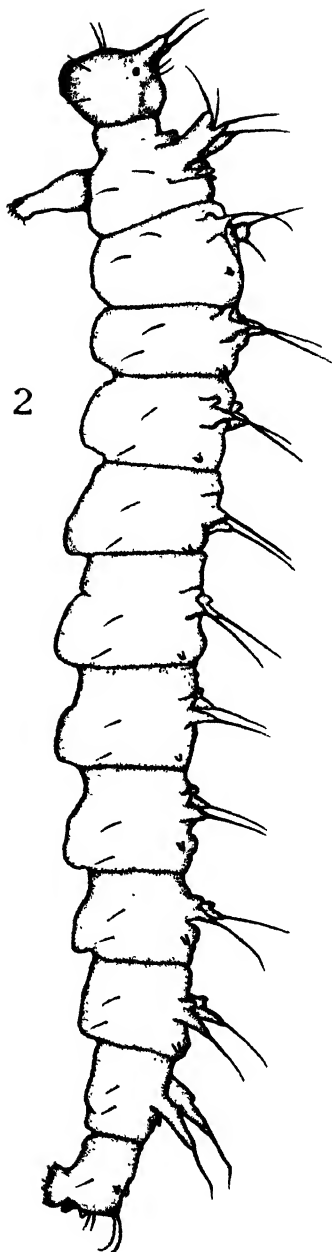
FIGURE 1. Eggs, several views. 2. Fourth-instar larva, lateral view.  
3. Pupa, lateral view.



1



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MWB

segments, the terminal segment being microscopic. Eyes undivided, at the bases of the antennal tubercles. Dorsum of head particularly ornamented with microscopic nodules.

Body segments nearly circular in sectional view, not conspicuously depressed. Each body segment except the last with a pair of conspicuous dorso-lateral projections, those on the first and second thoracic segments each bearing two setae, the rest only one. Projections on the first thoracic segment more than twice as long as their diameter; projections on the eighth abdominal segment tending to be compound. Second seta on the projections of the second thoracic segment about half as long as the first. Each body segment except the last bearing a pair of small projections behind the large setiferous projections and provided laterally with two hairs. Terminal segment with one hair on each side and two terminal hairs; also a pair of dorso-terminal setae on poorly developed projections. Body ornamented with microscopic conical nodules.

Anterior prolegs elongate, fused to near apex; posterior prolegs short.

Color of living larva commonly uniform dull yellow, greenish yellow, or yellowish brown. Head more or less translucent to black, becoming progressively darker as the stadium progresses. As the time of pupation approaches, a median dorsal yellow body line may appear. Later, the yellow may be extended so as to give the following pattern: first thoracic segment yellow; middle of the other thoracic and the abdominal segments yellow, the dorso-lateral margins between the projections orange-brown; eighth abdominal segment with orange-brown areas continuous between the right and left dorso-lateral projections which seem to be connected by a sclerotized area; ninth abdominal segment above wholly orange-brown and sclerotized.

Length, 2.3 to 3.3 mm. Width of head capsule, 0.20 to 0.28 mm.

*Pupa* (figs. 3 and 8).—Thoracic dorsum with five pairs of bristles, as follows: two dorsal pairs nearly forming a square on the disc of the scutum; an anterior pair between the anterior dorsals and the respiratory trumpets; a smaller lateral pair between the anterior dorsals and the wing pads; and an exceedingly inconspicuous, decumbent, transparent posterior pair behind and mesad of the posterior dorsals with the tips lying between the bases of the posterior dorsals.

Respiratory trumpets boot-shaped, clavate, flat, or cylindrical, depending on view.

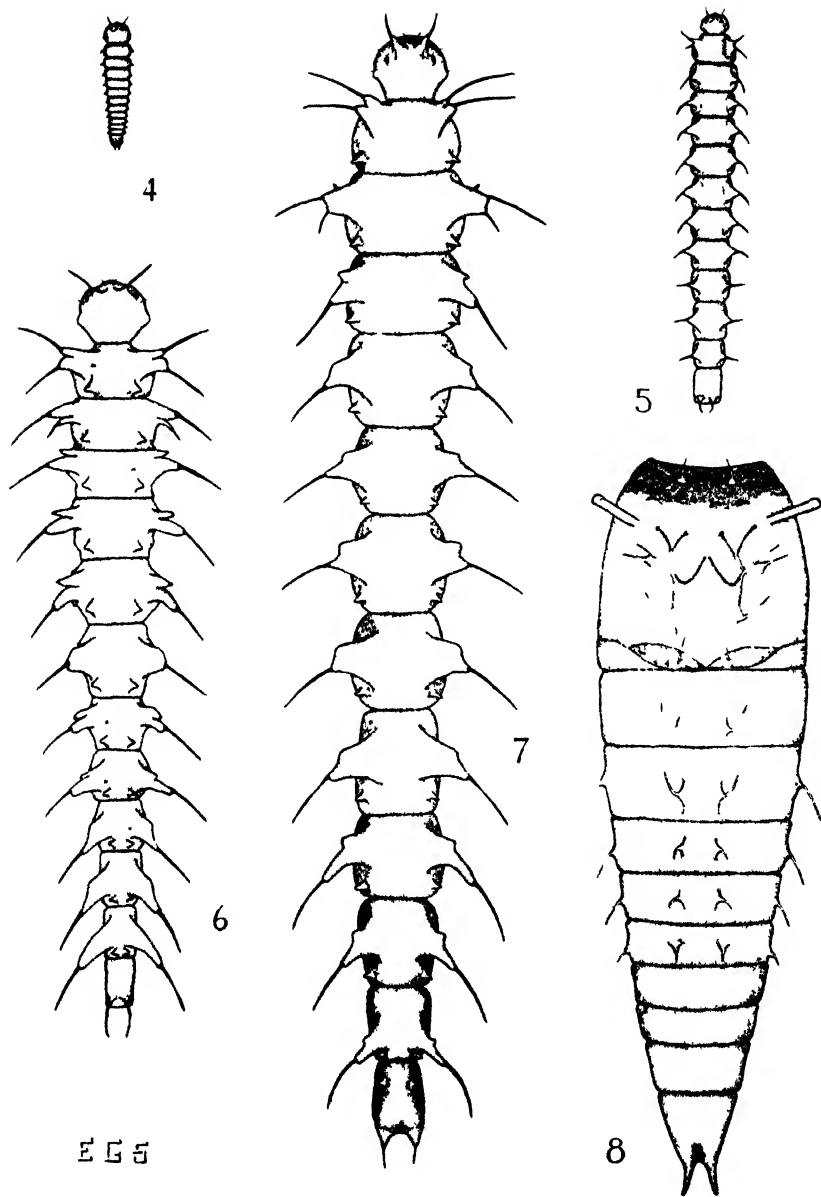
First to fifth abdominal segments each with a pair of dorsal bristles, the first and second pairs directed cephalad, the third to fifth pairs directed caudad. Second to fifth abdominal segments each with a pair of lateral bristles. Last four segments without bristles. Terminal segment forked, the projections directed posteriorly. Larval skin regularly remaining attached to the pupa and covering the abdomen posterior to the middle of the sixth segment.

Color of living pupa dull yellow to brown.

Length, 1.7 to 2.5 mm.

#### EXPLANATION OF PLATE II

FIGURE 4. First-instar larva, dorsal view. 5. Second-instar larva, dorsal view. 6. Third-instar larva, dorsal view. 7. Fourth-instar larva, dorsal view. 8. Pupa, dorsal view.



## KEYS TO NORTH AMERICAN SPECIES OF ATRICHOPOGON

*Atrichopogon levis* is the fourth American species for which larvae and pupae have been described. It may be noted here also that the early stages of this grass punky do not resemble at all closely those of any known Palaearctic species. Keys to the known Nearctic species are given, to some extent after Thomsen (1937).

## KEY TO LARVAE

1. First thoracic segment without conspicuous projections or processes; anterior abdominal segments with two longitudinal dark lines. . . . . 2
- 1'. First thoracic segment with conspicuous processes; dark, parallel, dorsal lines absent. . . . . 3
2. Black areas present dorso-laterally on first thoracic segment and laterally on eighth abdominal segment. . . . . **websteri**
- 2'. First thoracic and eighth abdominal segments without differentiated black areas. . . . . **fuscus**
3. Projections in some cases more than twice the diameter of the body segment on which they are located; processes on first thoracic segment not more conspicuous than those on second; abdomen conspicuously more bristly than thorax. . . . . **peregrinus**
- 3'. Projections including setae in no case twice the diameter of the body segment on which they are located; processes on first thoracic segment more conspicuous than those on second; abdomen not conspicuously more bristly than thorax. . . . . **levis**

## KEY TO PUPAE

1. Thorax with twelve bristles; last segment with projections at right angles to segment. . . . . 2
- 1'. Thorax with six or ten bristles; last segment with projections directed posteriorly. . . . . 3
2. Two thoracic bristles ending in a spine; respiratory trumpets boot-shaped. . . . . **fuscus**
- 2'. Six thoracic bristles ending in a spine; respiratory trumpets without heel-like projection near base. . . . . **websteri**
3. Thoracic bristles six; color largely black; anterior abdominal segments with branched lateral projections. . . . . **peregrinus**
- 3'. Thoracic bristles ten (one pair very inconspicuous); color brown; anterior abdominal segments with simple lateral bristles. . . . . **levis**

## BIOLOGY

*Length of the Life Cycle and Its Components.*—On the average, development from the laying of the egg to adult emergence requires about twelve or thirteen days under apparently favorable summer laboratory conditions. We have no information on the length of the preoviposition period. There is of course considerable variation in the length of the different stages. Speed of development seems to be greatly modified by environmental influences (see below). A reasonable estimate places the average length of the egg stage at about three days. In one case all of a series of twenty eggs, which were collected out-of-doors and segregated, had hatched within two and one-half days; fourteen had hatched within one day. The first three larval instars each require about one and one-half days, with variations noted between one and three days. The fourth larval instar however is longer, usually requiring about two and one-half days, with variations ranging principally between two and four days. The pupa likewise requires about two and one-half days with a range almost exactly the same as that of the fourth larval instar.

**Oviposition and Hatching of Eggs.**—*Atrichopogon* species of the Palaearctic region for which information is available lay eggs in masses, in aquatic situations. Nothing seems to have been published regarding the eggs of American species. It is therefore doubly interesting to note that females of *Atrichopogon levis* deposit their eggs singly on soil covered with algae, in shaded situations. If such soil is examined under the microscope, eggs may be found lying flat on the surface. Eggs have never been found concealed or embedded in any way. Unhatched eggs are firm and can readily be moved around with a fine dissecting needle. After an egg has hatched, the shell generally collapses and lies flat against the soil, but occasionally a shell will retain the original form and may then appear like an unhatched egg. Therefore eggs under observation were always gently probed to determine whether or not they had hatched.

**Larval Feeding.**—Soon after hatching the larvae begin feeding on the superficial algae. They grow quite rapidly, almost invariably showing a measurable increase in length within a period of two or three hours except near the time of ecdysis. All larval instars take the same food and feed in the same manner. Larvae viewed from the side could readily be seen to feed on the algae covering the soil in the dishes. An analysis of the stomach contents of several larvae revealed *Oscillatoria*, *Rhizoclonium*, and *Navicula*. Larvae generally move around slowly over the algae, feeding as they go. At each slight hesitation, a larva crops off the plants within its immediate reach. In this manner indistinct feeding trails are left among the soil algae. More distinct are the fecal trails which are almost continuous ridges of moist glistening material having a greenish or brownish cast and a varying diameter.

An analysis of surface material found where larvae were feeding revealed *Tetraspora* as the dominant algal genus; other genera recorded are *Lyngbya*, *Rhizoclonium*, *Chlamydomonas*, *Oscillatoria*, *Navicula*, *Pandorina*, *Trachelomonas*, *Oedogonium*, *Stichococcus*, *Chroococcus*, and *Spirogyra*.

**Larval Behavior.**—Larvae in general move around slowly over the soil surface in feeding but are otherwise inclined to be inactive, except possibly when they are reacting negatively to light. Later-instar larvae particularly have a habit of resting in shallow depressions in the soil where they may remain for long periods without moving, particularly in the latter part of the fourth stadium. In such resting individuals the anterior end sometimes jerks about nervously. Occasionally larvae were found with only their heads protruding from under the edges of partially embedded leaves or from small soil crevices. Now and then larvae were observed to be very dirty, as though they had been in the mud. It seems altogether probable that they sometimes actually burrow in the soil. Once it was suspected that they burrowed in the soil to molt, but that is certainly not always, if ever, the case. They molt on the soil, leaving the cast skin at the surface.

**Observations on Habitat.**—It may be noted here that all areas which we found supporting stages of *Atrichopogon*, whether in vineyards, near puddles, or along streams, are subject to occasional or periodic flooding and are more or less protected from drying out by shade from woody vegetation. Such intermittently wet areas support the growth of ter-



restrial algae and many normally aquatic ones. As these locations dry out, the algae continue to exist in a resting state.

The larvae originally found by Miss Clum were located under a clump of small willows growing in a rather poorly drained area in a vineyard. The ground at the time was moist and covered with a growth of algae.

Many larvae were also located in the general area of one of the sinks on South Bass Island. The hole of the sink is plugged to such an extent that water is only gradually lost through seepage and evaporation, so that a sizeable spring pond is gradually reduced to a small late-summer puddle. In that area, larvae were at first found in numbers along a cow-path under a clump of willows; they were on occasion particularly abundant in the cow-tracks where the ground was somewhat more moist than elsewhere. As the season progressed and the soil became more and more dry, larvae became increasingly scarce in the cow-track area under the willows but were found more plentifully under clumps of small willows nearer the center of the sink. Later, examination of the soil near the water revealed many eggs as larvae became scarcer under the clumps of small willows. Thus seems to be indicated an *Atrichopogon* successional movement in the direction of the center of the sink as conditions became increasingly dry.

*Moisture Relations.*—Habitat observations detailed above suggest that adults are probably very sensitive to moisture conditions in laying eggs.

Laboratory observations indicate that the larvae of the grass punky are not inclined to be aquatic. If the soil on which the larvae are being reared is made rather moist so that an evident water film covers the algae, the larvae invariably crawl up on the sides of the dish. This suggests that they would very quickly be driven out of an environment with even a slight excess of moisture.

However, habitat observations, as indicated above, suggest that dry soil is unfavorable for larvae, perhaps only because it does not promote algal growth. Attempts to collect larvae over a period of weeks demonstrated that, as the soil dried out, larvae became increasingly difficult to find, particularly the early instars, until finally only a few relatively inactive individuals could be found. Where conditions seemed favorable, early- and late-instar larvae were on occasion collected from the same cow-track.

*Temperature Relations.*—No accurate temperature records were kept but we could not help noticing a marked influence of temperature on rate of development. A series of cool days invariably impeded development in the dishes. On the other hand, warmth seemed to speed up development. On one occasion, two larvae were transported on a warm day about 130 miles in vials placed in the glove compartment of an automobile. One of the larvae died, but the other passed through the third instar in about twenty-four hours, the shortest time recorded for that instar.

*Pupation and Pupal Activities.*—Pupation occurs on the soil surface. As in other species of *Atrichopogon*, the larval exuvium remains attached to and covers the posterior end of the pupal abdomen. On a flat surface, pupae lie with the ventral side down. In the dishes, under laboratory conditions, pupation often occurs next to a piece of plant

material or next to the earth on the paper or at the outer edge of the towel paper. Occasionally pupae are found attached to bits of dead vegetation projecting from the earth.

Pupae are usually inactive and show no tendency to move. However, if the anterior end is touched lightly with a dissecting needle, the body except for a few posterior segments is tossed backward vigorously, sometimes to an extent of more than ninety degrees, and is held there for about half a minute; then it suddenly jerks back into its original position against the substratum.

*Habits of Adult.*—The senior author has taken adults of *Atrichopogon levis* in almost unbelievably great numbers, particularly in Illinois. So abundant is this species in short grass in Illinois that we came to call it the "grass punky," a common name which has been adopted in this paper. The species abounds in the short grass of parks, lawns, cemeteries, and roadsides but is by no means confined to such locations. Adults are likewise abundant in some Ohio localities. Frequently males have been taken from swarms which appear with considerable regularity at about the time when the sun is approaching the horizon, or at other times providing a roughly equivalent light intensity. Swarms may occur in the same limited area evening after evening and year after year. Swarming territories swept just after dark, when the punkies are no longer visible, may yield both males and females; the implication is that mating occurs under such circumstances. Swarms commonly center about two or three feet from the ground but may rise considerably higher.

Although most of the observations reported in this paper were made at Put-in-Bay, the adults seem to be rather rare in the Put-in-Bay region. Cemeteries, lawns, and a variety of other situations have been swept systematically, usually without success. Lighted store windows in the downtown area, which are in many places productive on dark nights, have at Put-in-Bay given completely negative results, although thousands of Tenebrionidae crowded about some of the lights. Nor have adults been seen swarming at Put-in-Bay. Adults are very common at Oxford, where they have been taken as early as May 14 and as late as October 21. Malloch (1915) records them for Illinois from April 18 to November 24.

Adult males and females have been found flying in rather broad daylight above moist mud encrusted with algae. It has not been established however just when oviposition takes place. Such mud may be so moist as to show no cracks; in other cases, drying out may have proceeded to the extent that one-eighth inch cracks are visible. Adults have been collected along streams as well as near stagnant water.

The writers have been unable to learn anything about the food habits of the adults.

*Overwintering.*—Attempts have been made to find stages of the grass punky in winter but results have been negative. After the early stages had been worked out, the senior writer happened to recall receiving from Dr. P. C. Stone in 1940 an unknown larva which seemed to belong to the genus *Atrichopogon*. Upon checking this individual it was found to be a third-instar larva of *A. levis*. We are deeply indebted to Dr. Stone for information concerning the circumstances surrounding the discovery of that larva. It was taken from the nest of the prairie

meadow mouse, *Microtus ochrogaster* (Wagner), in Urbana, Illinois, on January 22, 1939. Dr. Stone states that another specimen was collected from grass above the nests on November 22, 1939, and suggests that larvae found in the nests "had probably been brought into the nests on the grass nest material." We know then that third-instar larvae occur in midwinter. The fact that Dr. Stone in his careful study of nesting material reported no other stages suggests that the larvae are inactive. A necessary association between *A. levis* and *M. ochrogaster* must not however be assumed, for *Microtus* is not known to occur on South Bass Island where larvae were located in some abundance. The house mouse, *Mus musculus* L., and the white-footed mouse, *Peromyscus leucopus* (Raf.), are nevertheless present on that island. Possibly there is a winter connection between the grass punky and rodents.

### SUMMARY

1. All of the early stages of *Atrichopogon levis* are terrestrial.
2. The period between oviposition and adult emergence under favorable conditions is about twelve or thirteen days, the duration of the respective stages being roughly as follows: egg, three days; larva, seven days; pupa, two and one-half days.
3. Eggs are laid singly and flat on the surface of moist soil covered with algae, in shaded situations.
4. Eggs are black, subshining, slightly curved, and average 0.39 mm. in length and 0.10 mm. in width.
5. All larval instars feed on algae.
6. There are four larval instars ranging in length from 0.38 to 3.3 mm. and with average head capsule widths as follows: first, 0.09 mm.; second, 0.12 mm.; third, 0.17 mm.; fourth, 0.23 mm.
7. The full-grown larva differs from other known American *Atrichopogon* larvae in having prothoracic projections which are well developed and distinctly more prominent than are the mesothoracic projections.
8. Inasmuch as larvae are dependent on algae on the soil for food, a given environment is likely to remain favorable to them for only a limited period of time.
9. Pupation occurs at the soil surface where pupae remain essentially in an inactive condition.
10. Pupae average 2.2 mm. in length and differ from other known American *Atrichopogon* pupae in having ten thoracic bristles.
11. Adults may be exceedingly abundant in the short grass of lawns by day. Swarming commonly occurs at dusk, a few feet from the ground.
12. The grass punky probably overwinters as an inactive larva.

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# CORRELATION BETWEEN MANDIBULAR MORPHOLOGY AND FOOD SPECIFICITY IN GRASSHOPPERS<sup>1</sup>

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## INTRODUCTION

The adjustment between food and mandibles of biting insects is so definite that entomologists find little of phylogenetic value in the various mandibulate patterns (Walker, 1933, p. 325). The specialization of mouth parts for different foods is a basic fact recognized in all entomological study (Snodgrass, 1935, p. 280). Food specificity among insects has for some time been a major problem with many experimental, economic, and field entomological investigators. Brues in a series of studies has emphasized the biological significance in insect food adaptations, especially for studies in evolution.

The morphology of the mandibles and other mouth parts of the Orthoptera and related insects has been investigated by Nininger (1915), Yuasa (1920), Golden (1925), Snodgrass (1928), Petrov (1905), in Uvarov, 1928; the paper by Petrov has not been seen by the writer; Walker (1933), *et al.* Uvarov (1928, p. 4) calls attention to the marked variability of the mandibulate "teeth" among the different species of the Acrididae.

In the literature at hand, however, no mention is made of special adaptations of mandibles by phytophagous grasshoppers to different types of vegetation or plant parts, such as grasses, forbs, buds, flowers, and seeds. The fact that there is deep-rooted misinformation to the effect that grasshoppers eat "everything green," or at least that all grasshoppers eat grass, may have inhibited inquiry into the obvious evolution of acridian mandibles to variations in host plant tissues.

Students of mammalian evolution and adaptation have long emphasized the adjustment of teeth to varying types of vegetation. Scott (1924), in discussing the history of herbivorous land mammals, points out that "such teeth imply that their possessors must have fed habitually upon a softer less abrasive diet than grasses, probably leaves of soft shoots of trees and bushes and other succulent vegetable sub-

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<sup>1</sup>The term grasshopper in this paper follows the usage of many American authors and includes the Acrididae (short-horned grasshoppers) and the Tettigoniidae (long-horned grasshoppers).

<sup>2</sup>The writer wishes to thank Dr. Eleanor B. Scott and Dr. Gordon Alexander for reading the manuscript and making helpful suggestions. He is indebted to Dr. J. R. Parker for suggestions and literature, to Robert E. Pfadt and Roy F. Fritz for the use of their unpublished notes and records dealing with food preferences and subsistence foods of grasshoppers. My thanks are due to Ruth Maxwell Sanders for drawings of figs. 1 and 2, and to Kisa Noguchi for drawings of figs. 3 and 4. Helpful technical assistance has been given by Mary N. Isely, Tarver Morris, Walter B. McCall, and Martha Orr.

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stances." Botanical authors call attention to the compact leaf tissues of grasses composed of epidermis, sclerenchyma, and encased vascular bundles. Dr. Francis Ramaley in a letter to the writer (June 20, 1941, Boulder, Colorado) emphasized plant tissue differences, "Both stems and leaves of grasses contain much more silica than the corresponding parts of broad-leaved herbs. Grass stems have, in nearly all cases, the sub-epidermal sheath of sclerenchyma, and this as well as the epidermis and the hypoderma is usually highly silicified. Broad-leaved plants do not have as much sclerenchyma in their stems as grasses. The leaves have almost no silica."

#### FOOD SPECIFICITY

In earlier papers the writer has shown that many of the common species of grasshoppers (Acrididae and Tettigoniidae) of north-central Texas are selective feeders and that the Acrididae are for the most part strictly oligophagous. Since the mandibles are the principal biting and chewing organs of these grasshoppers, it has seemed worth while to investigate the adaptations to different types of vegetation, not only of the acridians feeding on grasses and forbs, but also of the plant-feeding and predaceous insect-eating Tettigoniidae. Preliminary studies were reported (abstracts, Isely and McCall, 1938; Isely, 1938b, 1941b). The present paper, which is a direct sequel to my published food preference researches, has awaited further field observations and cage testing of grasshopper food preferences and food subsistence diets.<sup>3</sup>

Previous cage studies involving forty species of the Acrididae have indicated that these short-horned grasshoppers fall roughly into two nearly equal groups, the grass feeders and the forbs feeders (Isely, 1938a, p. 586). A number of acridian species, while belonging primarily to one group or the other, are found to be mixed feeders, eating both forbs and grasses. Usually the mixed feeders may further be subdivided into (1) forbs-grass eaters and (2) grass-forbs eaters, according to whether first preference and subsistence food plants are found among the forbs or the grasses.

The fact that grasshoppers need specific diets for maximum longevity and fecundity has been demonstrated by several investigators, especially by the researches of Carothers (1923), Criddle (1933), Isely (1938a, 1941a), and Sanderson (1939). The cage studies for the present work and the unpublished experimental records of Pfadt<sup>4</sup> (1940, 1941) and Fritz<sup>5</sup> (1940) further emphasize the importance of food specificity for

<sup>3</sup>New data based on further investigations by the writer and not previously reported (Isely, 1938a and 1941a) are herein briefly summarized and are referred to as "summers 1939, 1940, 1941."

<sup>4</sup>Unpublished notes by Robert E. Pfadt, employed cooperatively by the Wyoming Experiment Station and the Bozeman Laboratory of the Bureau of Entomology and Plant Quarantine. The progress reports covering Mr. Pfadt's investigations for the summers of 1940, 1941 are on file at the Wyoming Experiment Station and the Bozeman Laboratory. These records were made available to the writer through the kindness of Professor C. H. Gilbert, Dr. J. R. Parker, and Mr. Pfadt and are referred to in this paper in the same way as other "Literature Cited" (Pfadt, 1940 or 1941).

<sup>5</sup>Mr. Roy F. Fritz, of the Kansas Experiment Station and the Garden City Area, has also kindly provided me with a summary of his "Food preference tests with *Aeoloplus turnbulli bruneri* Caudell" which were conducted in the Garden City Area, summer 1940.

optimum individual grasshopper maintenance, reproductivity, and species survival. The Tettigoniidae have not been as extensively tested as to their food preferences as have the Acrididae, but their diet requirements are also found to be specific. Certain species of the Tettigoniidae (Isely, 1941a) are found to select forbs or their flowering parts as food; others are wholly predaceous; and several species feed chiefly on the seeds of grasses.

#### MORPHOLOGY OF MANDIBLES

The asymmetry of grasshopper mandibles and the fact that the left mandible overlaps the right have been discussed and figured by Snodgrass, Uvarov, and others. The differentiation of the mandibles in biting and chewing insects has been emphasized by Metcalf (1929). For the present report the morphology of the mandibles of over one hundred and ten species of Acrididae and Tettigoniidae were macroscopically and microscopically examined. The parts of the incisor and molar lobes of these mandibles were checked for their gross histology. The mandibles of a number of individuals of several species were examined to note variations within the species; permanent mounts of mandibles were made; and the structures of the jaws of the several instars were studied and compared. For most species, however, the mandibles of only two or three specimens were examined from temporary mounts in water, alcohol, or plastic. To make the data on food specificity and mandibular correlation as complete as possible, all available records of food preference experiments of specific species of grasshoppers have been carefully checked.

#### MANDIBLE PATTERNS OF THE ACRIDIDAE

##### REPRESENTATIVE MODELS

*Brachystola magna* (Girard).--The morphology of the biting jaws of *B. magna*, the western lubber, also called the jumbo grasshopper, is selected as representative of those species which feed primarily on forbs and whose maintenance requires a diet made up of forbs. The chief morphological features of the jaws of *B. magna* are well depicted in fig. 1. The characteristic asymmetry and the fact that the left mandible overlaps the right is indicated in the anterior-ventral view (fig. 1, RA and LA). The left incisor lobe of *B. magna* is distally marked along the cutting edge by four well-defined dentes (ID). Only three dentes show prominently in the cutting edge of the right incisor lobe (RA), as dens No. 4 is smaller and back of No. 3. The mesial molar lobes likewise have several dentes which interlock in the chewing process. In comparison with mammalian tooth patterns (Scott, 1924), the molar areas of typical forb feeders may be described as mastodontic. The molar area of the left jaw of *B. magna* is usually formed by four dentes surrounding a concavity in which two smaller denticles appear (fig. 1, LM). The general pattern of the molar lobe of the right jaw is well pictured in fig. 1. Six dentes of varying size surround the concavity of the right molar area (fig. 1, MD, ML). In chewing and triturating the leafy forbs these molar denticles of the right and left jaws are interspaced so as to form an efficient masticatory mechanism for eating the leaves, buds, and stems of the broad-leaved plants which constitute their diet.

*B. magna* is characterized by Hebard (1931) as belonging to the plains fauna of western U. S. extending from Texas to Montana. The writer has collected the western lubber on the western border of north-central Texas, in the Panhandle, and in the Trans-Pecos. Parker (1933) lists *B. magna* as one of the minor economic acridian species. In Texas, however, it is known at times to do considerable damage to cotton. In my cages *B. magna* fed by preference on such forbs as *Gossypium* (cotton), *Gaillardia*, *Ambrosia*, *Helianthus*, *Lactuca*, *Parthenium*, and other coarse weeds and garden plants. Among the weeds refused were *Amaranth*, *Croton*, *Euphorbia*, *Lepidium*, *Monarda*, *Solanum*, and *Verbena*. Young corn and succulent weed grasses were eaten, but in much smaller quantity when compared with palatable forbs. The feces in the cages containing grass were always sparse, dry, and light. Mature native grasses including *Andropogon*, *Sporobolus*, and *Buchloe*, as well as mature exotic Johnson and Bermuda grasses, were only nibbled. Four males placed in a cage June 19, 1941, and supplied regularly with mature grasses all died on the ninth day,

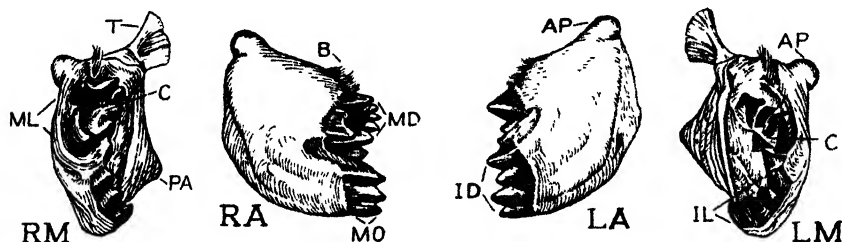


FIGURE 1. Forbivorous mandibles of *Brachystola magna* (Girard). RM, right mandible, mesial view; RA, right mandible, anterior-ventral view; LA, left mandible, anterior-ventral view; LM, left mandible, mesial view. The mesial views are secured by turning the mandibles out from anterior-ventral position. AP, anterior articular process; B, brustia; C, concavities of molar areas, formed by molar dentes; ID, incisor dentes; IL, incisor lobes; MD, molar dentes; ML, molar lobes; MO, margin of overlapping by left mandible; PA, posterior articular process; T, tendon adductor muscles.

June 28. In a second cage two pairs of *B. magna*, even when supplied with succulent grasses and corn, soon died and the eggs of dissected females apparently had deteriorated. In cages which were supplied with palatable forbs, other pairs of *B. magna* were feasting greedily, copulating, and ovipositing. There can be no doubt that, while *B. magna* will at times feed on corn and young grasses, perhaps even to the extent of economic damage, it requires a diet of a limited number of forbs for its successful maintenance and fecundity.

The avidity with which *B. magna* feeds on fallen comrades crushed by passing automobile or wagon wheels has been given as evidence that the species is predaceous and carnivorous. This suspicion is not confirmed by cage observations under starvation pressure.

*Mermiria maculipennis* Bruner.—This prairie acridian was chosen as a typical representative of the graminivorous species. Its food preferences were thoroughly tested by the writer (1938a). This species

quickly starved on a cage diet of fresh forbs which represented the favorite host plants of the forbivorous acridian species on the insectary shelves. The mandible patterns are well represented in fig. 2. The contrast with *B. magna* is striking. These differences are well shown in the anterior-ventral views of the molar lobes. The distal cutting edge of the left incisor lobe (fig. 2, LA) is more continuous than the jagged cutting edge of the incisor lobes of the forbs feeding *B. magna*. The four incisors fit closely together and are marked off by shallow grooves. The left jaw only slightly overlaps the right (RA) and the distal edge of the right incisor lobe is beveled (BV) to meet the incisor edge of the overlapping left lobe. The poorly defined individual denticles of the incisor lobe of the right mandible of *M. maculipennis* are indicated by a roughened row of denticles on the distal incisor edge. The individual incisors are barely indicated by shallow grooves on the outer concave surface of the right incisor lobe. The molar areas (ML) are likewise distinctive and different from the molar lobe surfaces of *B. magna*. Ridges and furrows (RF) make up the grinding surfaces of the broad mesial molar

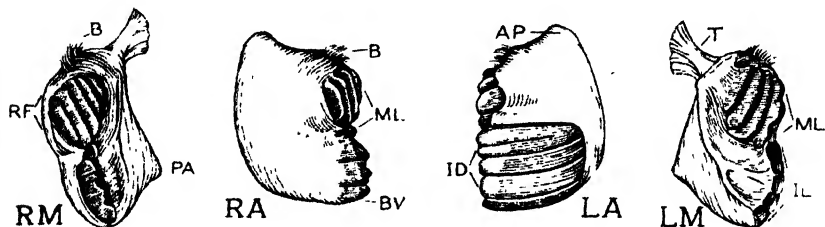


FIGURE 2. Graminivorous mandibles of *Mermiria maculipennis* Bruner. RM, right mandible, mesial view; RA, right mandible, anterior-ventral view; LA, left mandible, anterior-ventral view; LM, left mandible, mesial view. BV, beveled edge where left incisor lobe overlaps right incisor lobe; RF, ridges and furrows characteristic of molar pattern of graminivorous species; other parts as in fig. 1.

lobes of these grass feeders. When compared with mammalian tooth structure the graminivorous species may be described as mammoth-like in their molar patterns. While *M. maculipennis* is typical of the grass feeders, there are several other species both of the Acridinae and the Oedipodinae which have more highly specialized graminivorous mandible patterns. Frequently in these species the incisor denticles are entirely fused and form a continuous cutting edge. The furrows are shallower and the ridges less evident than those of the mandibles of *M. maculipennis*.

In Texas, *M. maculipennis* is one of the most characteristic of the prairie grasshoppers and, in favorable habitats, one of the most abundant. Rehn (1919, p. 107) remarks that "The occurrence of this species as a whole, as throughout the genus, is governed by the distribution of grass patches or continuous grass prairie." In north-central Texas, large populations of *M. maculipennis* are frequently found in the few remaining prairie grass pastures where conservative grazing has been practiced. It is worthy of notice, however, from the food pref-



erence viewpoint, that the writer's field records show *M. maculipennis* reaching population peaks in this area (north-central Texas) in a mixed growth of exotic grasses, Johnson and Bermuda.

*Melanoplus differentialis* (Thos.).—This species, frequently called the yellow grasshopper, is the most important economic acridian of north-central Texas. The food habits of *M. differentialis* have been critically studied by experimental zoologists and economic entomologists. In this work, the morphology of the jaws of the yellow grasshopper has been more thoroughly checked than those of any other acridian species. Many permanent and temporary mounts, as well as mounts of mandibles of all the several instars, were repeatedly checked.

The incisor lobes of *M. differentialis* are typically forbivorous. In an anterior-ventral view (fig. 3, LA) the four dentes of the left incisor lobe are as individually marked as are the dentes of *B. magna* (fig. 1, LA). The right incisor lobe is also similar in make-up to the typical forbivorous pattern. On the other hand, the denticles of the molar

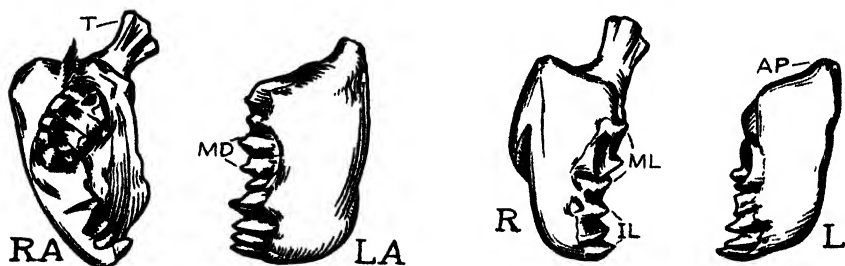


FIGURE 3. Herbivorous mandibles of *Melanoplus differentialis* (Thos.) (RA and LA), and florivorous-forbivorous mandibles of *Amblycorypha parvipennis* Stål (R and L).

RA, right mandible, mesial view, and LA, left mandible, anterior-ventral view, of *differentialis*. R and L, anterior-ventral-mesial views of right (R) and left (L) mandibles of *parvipennis*. These views are secured by turning the mesial margins of mandibles from the straight front anterior-ventral position slightly outward. AP, anterior articular process; IL, incisor lobes; MD, molar denticles; ML, molar lobes; T, tendon.

lobes of *differentialis*, although mastodontic in appearance, are arranged in a ridge-furrow pattern and approach an intermediate condition between the forbivorous and graminivorous models. The herbivorous acridian mandible pattern is based on this combination model as found in *differentialis* and is characteristic of the mixed feeders among the Cyrtacanthacrinae and Oedipodinae. Another morphological feature which characterized the *Melanopli* and the forbivorous Oedipodinae is found in the two large marginal molar dentes (MD) as shown in *differentialis* (fig. 3, LA) when compared with the single prominent marginal molar dens of *B. magna*.

The variations in the molar patterns of *M. differentialis*, however, are definitely marked. These variations range from a near approach to the mastodontic irregular arrangement of the molar dentes forming the grinding surfaces of conservative forbs feeders to the regular roughened

furrows and ridges not unlike the molar surfaces of certain graminivorous species.

To test further the food requirements of *M. differentialis* a series of cages was started May 19, 1941, stocked with specimens of first and second instar juveniles collected in the field. One set of caged hoppers was fed on a diet made up wholly of mixed grasses and another set on a diet wholly of mixed forbs.

The chief grasses supplied were *Andropogon saccharoides* Swartz and *Sporobolus heterolepis* A. Gray, the most abundant native prairie grasses. From the exotic group *Sorghum halepense* (L.) Pers. (Johnson grass) and *Cynodon dactylon* (L.) Pers. (Bermuda grass) were regularly provided. Among the crop plants only *Zea mays* L. was supplied. In addition several weed grasses were fed from time to time, but these were not always checked for species. Usually mature grass leaves were used such as were eagerly eaten by graminivorous acridians in other cages on the insectary shelves. Among the chief broad-leaved plants in the forbs cages were shoots of *Helianthus annuus* (L.), *Ambrosia aptera* (DC.), *Lactuca virose* (L.), *Gaillardia pulchella* (Four.), and *Parthenium hysterophorus* (L.). Representatives of the first three weeds in the above list in pure or mixed patches and Johnson grass are the most frequent indicators of thriving colonies of *M. differentialis* in north-central Texas.

The first adult appeared in one of the forbs cages on June 28. On July 7, there were ten adults and two last instars in this cage. In the grass cages, the first adult appeared July 9, and on July 17 there were ten adults in a total of twenty-two specimens. The individuals in the forbs cages completed their transformation and became adult on an average of twelve days earlier than the individuals raised in the grass cages. The forbs cage specimens were definitely larger and appeared more vigorous than the individuals in the grass cages.

#### MANDIBLES AND FOODS OF OTHER ACRIDIDAE

In addition to the more detailed account of the mandibular morphology of the three species described above, the correlations between mandible structure and plant structure of eighty-six other species of the Acrididae are here briefly outlined and summarized. On the basis of fundamental similarity of mandible patterns these species belong to the subfamilies Acridinae (slant-faced grasshoppers), Oedipodinae (band-winged grasshoppers), Romaleinae (lubber grasshoppers), and Cyrtacanthacrinae (spine-breasted grasshoppers).

The species studied were usually those which were available for cage testing. They belong chiefly to the acridian fauna of north-central Texas; however, several species are from other areas of Texas and Colorado. As already stated in making his correlation analysis, the writer has used the critical cage studies of food preferences made by other investigators in addition to his own. The field activities of all the species here considered have been personally observed by the writer, and in most instances have been studied under field conditions for several years. Field records are of value chiefly to corroborate the host plant preferences of acridian species indicated in cages and as clues to other plants which may serve as food. It must be admitted that field evidence of food choices by grasshoppers is very illusive and easily misinterpreted.

From the viewpoint of phylogeny it is found that the majority of the species of a given genus or even subfamily have similar food preferences and hence have a general similarity in mandible patterns. However, if a species has changed in its food choices from the diet requirements of the majority of species in its subfamily or genus, the morphology of both mandible lobes (incisor and molar) has become adapted to the varying toughness of the plant tissues making up its diet. These mandible adaptations and phylogenetic divergencies are clearly shown in representative species of the Acridinae.

### Acridinae

In this subfamily only three species of the twenty-four Acridinae studied have forbivorous mandible patterns. These three forbs feeders are *Acrolophitus variegatus* (Thos.), Isely, 1938, p. 569; *A. hirtipes* (Say), Criddle, 1933, p. 478; and *Boottettix argentatus* Bruner. The third is a Trans-Pecos, Texas, species and is always found in the field to be closely associated with *Larrea tridentata* (DC) Coville. In the writer's cages (1939), *B. argentatus* fed exclusively on the leaves of *Larrea*.

*Graminivorous Mandibles*.—With the exception of the three species noted above, all other Acridinae here reported have graminivorous mandibles. Several of these species have more highly specialized mandibles than those of *Mermiria maculipennis*. This specialization is expressed in the fusion of the dentes of the cutting edges of the incisor lobes and in shallow furrows and flattened ridges in the molar areas. As a result these species are adapted to use as their standard diet the compact abrasive tissues of the leaves of mature grasses.

The following Acridinae have graminivorous mandibles: *Mermiria texana* Bruner, *M. neomexicana* (Thos.), *M. maculipennis* Bruner, *M. m. macclungi* Rehn, *Achurum sumichrasti* Sauss., *Tryxalis brevicornis* (L.), *Mesochloa abortiva* Bruner, *Syrbula admirabilis* Uhler, *Opeia obscura* (Thos.), *Amphitornus coloradus* (Thos.), *Amblytropida occidentalis* (Sauss.), *Phlibostroma quadrimaculatum* (Thos.), *Orphulella pelidna* (Burm.), *O. speciosa* (Scud.), *Dichromorpha viridis* (Scud.), *Ageneotettix deorum* (Scud.), *Psoloessa texana* (Scud.), *Boopedon nubilum* (Say), *B. maculatum* Caudell, *B. auriventris* McNeill, and *Aulocara ellioti* (Thos.).

As far as the writer's cage evidence gives information, only one of the above species, *Ageneotettix deorum* (Isely, 1938a, p. 581-2) indicated that under starvation pressure it would turn to forbs for food. This appears to be in line with field evidence cited by Allred (1941) for *A. deorum* and *Aulocara ellioti* where these species are credited with the destruction of sagebrush, *Artemisia tridentata*. However, in Pfadt's cages (unpublished records) these range grasshoppers soon died when supplied only with fresh alfalfa.

### Oedipodinae

The oedipodines have a wide range of food preferences and are a heterogeneous subfamily in their diet requirements. Here are found (1) obligatory, graminivorous species, (2) oligophagous, forbs feeders, and (3) mixed feeders. The mandible patterns of the band-winged grasshoppers are as variable as are their food choices. A number of

species in this subfamily have been cage tested by the writer, and experimentally checked for food choices by Criddle (1933), et al.

The species of the Oedipodinae, as were the Acridinae, are grouped below on the similarity of mandible models. This grouping is found to parallel feeding behavior.

*Grass-Feeder Mandible Patterns*.—*Arphia xanthoptera* (Burm.), *A. simplex* Scud., *Chortophaga viridifasciata* (DeGeer), *Encoptolophus subgracilis* Caudell, *E. sordidus costalis* (Scud.), *Hippiscus rugosus* (Scud.), *Pardalophora saussurei* (Scud.), *Dissosteira longipennis* (Thos.), *Trachyrhachis kiowa fuscifrons* (Stål).

*Forbs-Feeder Patterns*.—*Xanthippus corallipes leprosus* Sauss., *Cratypedes neglectus* (Thos.), *Tropidolophus formosus* (Say), *Spharagemon bolli* Scud., *S. equale* (Say), *Trimerotropis pistrinaria* Sauss., *Hadrotettix trifasciatus* (Say).

*Mixed-Feeder Patterns*.—*Arphia conspersa* Scud., *A. pseudonietana* (Thos.), *Camnula pellucida* Scud., *Xanthippus corallipes pantherinus* (Scud.), *Leprus cyaneus* Cockerell, *Dissosteira carolina* (L.), *Spharagemon collare cristatum* (Scud.), *Trimerotropis citrina* Scud.

In the mixed-feeder group among the oedipodines, grasses are found to be the preferred diet and the mandibular structure, while intermediate, is clearly nearer the patterns of the graminivorous species. The depredatory warrior grasshopper, *Camnula pellucida*, which has been studied by Parker (1930), Criddle (1933), and other economic entomologists, is primarily a grass feeder and notably destructive of cereal crops in the northern United States and Canada. *C. pellucida*, however, will also damage other field crops. *Dissosteira longipennis*, a range grasshopper and grass feeder, has been known to destroy beets and Irish potatoes (*in litt.*, Sam C. McCampbell, Extension Entomologist, Fort Collins, Colorado, October 20, 1941). Yet its mandible pattern is strictly graminivorous. One of the most puzzling species is *Xanthippus corallipes pantherinus*. The mandible pattern of the incisor lobes alone places it with the mixed feeders. The molar surfaces, however, are nearer the graminivorous group, although the furrows and ridges are rough. This species was thoroughly tested (1938a), and rechecked for the present work. In my cages, (summer, 1941) *X. c. pantherinus* lived for a considerable period roosting and nibbling at times on a wide assortment of forbs, but finally starved when grasses were absent from the vegetation provided in the cages.

### Romaleinae

In a recent comparative study of the subfamilies of the Acrididae, based primarily on their phallic structures, Roberts (1941) has formed the new subfamily Romaleinae. In this subfamily are brought together several North American species which were formerly placed by various authors in the subfamilies Oedipodinae, Batrachotetriginae, or Cyrtacanthacrinae. The mandibles of the following species of the Romaleinae were examined: *Phrynotettix tschevavensis* (Haldeman), *P. robustus* (Bruner), *Taeniopoda eques* (Burm.), and *Brachystola magna* (Girard).

In mandibular morphology all of these are forbivorous since their jaw patterns are similar to those of *B. magna* described above. In Texas the first three of these species are found only in the Trans-Pecos.

Although the mandibles are highly adaptive, a fundamental subfamily pattern has been observed for a large majority of the species which belong to a given grasshopper subfamily. The mandibular structural parallelism of these species of Romaleinae which were variously classified by previous authors would appear to accord with Robert's revision which is based on a stable acridian character.

### Cyrtacanthacrinae

The spine-breasted grasshoppers subsist for the most part on the leaves of forbs. A few species feed chiefly on the leaves of shrubs and trees. The mixed feeders which in this group are forbs-grass feeders will eat grasses when forbs are not available. Economic species, which are usually mixed feeders, will attack alfalfa, other legumes, cotton, corn, small grain, garden crops, and trees, apparently more or less indiscriminately. This polyphagous feeding behavior, which is characteristic of less than twenty-five per cent of cage tested grasshoppers, has been assumed by most entomologists to apply to all grasshoppers.

The chief mandibular differences between mixed feeders and forbs feeders among the melanopli, schistocercas, and other spine-breasted acridians are especially in the structure of the molar lobes. Among the strictly forbivorous species the dentes of the molar areas are pointed, appear to be irregular in position, and are here designated as mastodontic, whereas among the mixed feeders the dentes of the molar areas usually become more regular in form and frequently assume the ridge-furrow pattern; the incisor dentes, however, tend definitely toward the regular forbs model with distinct pointed dentes. The ridges are higher and the furrows deeper among the mixed feeders (fig. 3, RA) than are the ridge-furrow patterns of the strictly graminivorous species.

*Forbivorous Mandibles.*—The following Cyrtacanthacrinae have jaws adapted to feeding on forbs: *Schistocerca damnifica* (Sauss.), *S. lineata* Scud., *S. shoshone* (Thos.), *Hypochlora alba* (Dodge), *Paraideмона punctata* (Stål), *Campylacantha olivacea* Scud., *Aeoloplus t. bruneri* Caudell, *Hesperotettix viridis* (Thos.), *H. viridis pratensis* (Scud.), *H. speciosa* (Scud.), *Melanoplus texanus* (Scud.), *M. discolor* (Scud.), *M. flabellatus* Scud., *M. glaucipes* (Scud.), *M. ponderosus* Scud., *M. ponderosus eumera* Hebard, *M. femur-rubrum* (DeGeer), *M. keeleri* (Thos.), *M. packardii* Scud., *M. flavidus elongatus* Scud., *M. impiger* Scud., *Paroxya atlantica* Scud., and *Dactylotum pictum* (Thos.).

The above grouping of the Cyrtacanthacrinae is on the basis of their jaw morphology. Certain pest species listed above as *femur-rubrum* and *packardii* are reported by economic entomologists to destroy wheat and corn. It is a safe forecast, however, that if these economic species, as well as the mixed feeder group which follow and are here designated as forbs-grass feeders, were experimentally tested to discover their optimum subsistence and reproductivity diets, they also (with the possible exception of *M. mexicanus*) would require foods consisting of selected forbs.

*Mixed Feeder Mandibles.*—*Schistocerca americana* (Drury), *S. obscura* (Fab.), *S. alutacea* (Harris), *S. vaga* (Scud.), *Melanoplus scudderi* latus Morse, *M. differentialis* (Thos.), *M. bivitatus* Say, *M. confusus* Scud., *M. mexicanus* (Sauss.), *Phoetaliotes nebrascensis* (Thos.).

Four species of the schistocercas were first cage tested for food choices during October 1941. All of these bird grasshoppers indicated that the leaves of trees and shrubs were high on their list of preferred foods. The choice of these ligneous foods is reflected in their mandible morphology, and in the main the forbivorous pattern is followed. *Schistocerca damnifica* and *S. alutacea* definitely selected the leaves of the oaks, *Quercus stellata* Wang (post oak) and *Q. marilandica* Muench (blackjack oak). These two grasshopper species are separated in the above grouping on the basis of jaw structure, although the food preference data thus far obtained would place them together. *S. obscura* and *S. americana* were less specific in their food choices, accepting herbaceous leaves and under pressure fed to a limited extent on grasses. Jones (1939, p. 326) reports *S. americana* as defoliating young apple trees in southwestern Missouri.

Dr. J. R. Parker has recently called the writer's attention to a paper by Howard (1894) on "Damage by the American Locust." Dr. Howard quotes a report on field observations by D. W. Coquillett who discusses with critical detail the differential feeding of great swarms of *Schistocerca americana* in Roanoke County, Virginia, during August 1894. Coquillett points out that certain kinds of trees were stripped of all of their foliage while the leaves of other species of trees were untouched by the locusts. He noticed that low succulent vegetation was not eaten while mature leaves of certain plants were consumed. These field observations by Coquillett tally well with the feeding behavior of *Schistocerca americana* as observed in my cages in the fall of 1941.

*Graminivorous Mandibles* -Only four species of Cyrtacanthacrinae were found to be near to the graminivorous mandible patterns: *Leptysmia marginicollis* Serv., *Paropomala wyomingensis* (Thos.), *Melanoplus infantilis* Scud., and *M. plebejus* Stål).

*Marginicollis* is a widely distributed lake and stream acridian and is called the cattail grasshopper by Ball (1936); *wyomingensis* is a plains species; *infantilis* is from Colorado; only *plebejus* belongs to the prairie acridian fauna.

As a group the Cyrtacanthacrinae are, by preference, forbs eaters. As a result the forbivorous model is the chief jaw pattern of the spine-breasted grasshoppers. Many of the Cyrtacanthacrinae are wholly forbivorous and starve or are unable to produce eggs if maintained on a grass diet. My cage investigations concerning food choices of twenty-two species of Texas Cyrtacanthacrinae show that only one, *Melanoplus plebejus*, indicated a definite food preference for grasses. Under starvation pressure *M. plebejus* will for a time subsist on forbs. Criddle (1933) in his experiments with the feeding behavior of Canadian spine-breasted acridians reports five graminivorous, fourteen forbivorous, and fifteen mixed feeder species. Eight of Criddle's fifteen mixed feeders have also been cage tested for food choices by the writer. All of these and probably most of the other seven Canadian species are actually forbs-grass feeders. Pfadt (summer 1940) found alfalfa as one of the first choice foods for eight species of Wyoming grasshoppers, all Cyrtacanthacrinae. Fritz (summer 1940) experimenting with large numbers of *Aeolophus t. bruneri* Caudell found that for maximum longevity and reproductivity this spine-breasted grasshopper required a diet of shoots

of the Russian thistle. This need of forbs in the diet of the Cyrtacanthacrinae for maintenance and fecundity would, judged by current literature, appear to be unusual, but further food preference tests will probably show that many species of the Acrididae the world over are dependent even to the extent of species survival on forbs for food.

Uvarov (1928) in his thorough summary and review of world "Locust and Grasshopper" literature quotes numerous authorities which call attention to selective feeding of even pest grasshoppers. On the basis of these citations, however, as well as his extensive first-hand knowledge of locusts and Orthoptera in general, Uvarov concludes that grasshoppers are primarily "graminaceous." In speaking of the Italian grasshopper, *Calliptamus*, Uvarov (1928, p. 286) states: "The feeding habits of *Calliptamus* are peculiar." After calling attention to the forbivorous feeding behavior of this grasshopper, he says: "This constitutes a sharp distinction between *Calliptamus* and the majority of the Acrididae, in which Graminae are the staple food."

On the contrary it should be noted that recent grasshopper food preference experiments cited above show that fully half of the acridians which were cage tested (Criddle, Isely, and Pfadt) require a diet of forbs for their normal, healthful maintenance, longevity, and reproductivity.

#### MANDIBLE PATTERNS OF THE TETTIGONIIDAE

The mandibular models of the several species of the Tettigoniidae examined are found as a rule to have a standard subfamily pattern in the structure of their incisor and molar lobes. The morphology of these mandibles is uniformly correlated with the food specificity of the species concerned. Although the number of species involved is much smaller, cage tests show that the Tettigoniidae have a wider range of food preferences than do the Acrididae. Hence, as would be expected, we find greater basic variations in jaw structure.

The mandibles of the katydids are similar in fundamental pattern to those of the forbivorous Acrididae. The mandibles of the predaceous and seed-eating Tettigoniidae, however, are quite different from any acridian models studied and these mandibles are adapted to foods only rarely used by the Acrididae.

The subfamilies considered are the Phaneropterinae, Pseudophyllinae, Corpiphorinae, Conocephalinae, and Decticinae. The mandibular morphology of representative species for each subfamily is briefly described.

#### Phaneropterinae and Pseudophyllinae

*Florivorous-forbivorous Mandibles.*—The mandibular morphology of *Amblycorypha parvipennis* Stål may be taken as representative of the flower-forbs feeders. In the anterior-ventral view of the partly spread incisor lobes of *A. parvipennis*, three dentes are seen, left and right, instead of four as in the forbivorous Acrididae (fig. 3, R and L). The individual incisor dentes are well separated, distinctive, and pointed. The molar lobes, while somewhat mastodontic, are proportionally much smaller in area than are the molar surfaces of acridians of similar size. These characteristics are shown in fig. 3. *A. parvipennis* was grown

from eggs to adult in cages during the spring and summer of 1941. This species proved quite hardy and easy to rear. The young tender leaves of several species of the Onograceae were especially acceptable as food although the buds and young leaves of several other forbs were eaten. Flowers were greedily eaten. Grasses in general were on the refused list. Cage studies and food habits of five other species of breeding phaneropterines (Isely, 1941a) appeared to emphasize the need of plant shoots in flower for optimum reproductivity. The fact that pollen grains are frequently abundant in the dissected crops of the katydids which were taken in the field emphasizes their fondness for a diet of flower parts. On account of the definite bud-flower relations of the phaneropterines which were studied in cages, their light mandibles are here designated as the flower-forbs mandibles.

In addition to the five species of Phaneropterinae previously cage tested for food preferences, two other species, *Scudderia furcata* and *S. texensis*, were checked during September and October, 1941, to discover their feeding behavior. It was found that these late summer bush katydids also have a marked fondness for flower parts although the leaves of woody shrubs, in addition to the leaves of herbs, were also on their menus. Riley (1874, p. 166) names oak-leaves as the preferred diet of *S. furcata*. (Listed as *Phaneroptera curvicauda* (DeGeer) by Riley, but as Blatchley indicates, the species he tested experimentally was *S. furcata*.) In general the jaws of the Phaneropterinae examined average proportionally smaller than the mandibles of the short-horned grasshoppers. While each species has individually distinctive jaw features, the flower-forbs mandibles are found to be characteristic of the following Phaneropterinae:

*Dichopetala emarginata* Bruner, *Arethaca constricta* Bruner, *A. ambulator* Hebard, *A. grillator* (Scud.), *Amblycorypha huasteca* (Sauss.), *A. parvipennis* (Stål), *A. uhleri* (Stål), *A. oblongifolia* (DeGeer), *Scudderia texensis* Sauss. and Pictet, and *S. furcata* Bruner.

*Lignivorous Mandibles.*—The Pseudophyllinae are represented by a single species in north-central Texas, *Pterophylla furcata laetifica* Hebard. This subspecies was recently described by Hebard (1941). The same species was listed by the writer (1941a) as *Pterophylla camellifolia* (Fab.). The mandibles of this arboreal katydid are similar in their basic make-up to those of the flower-forbs model, but differ in certain features. The cutting edge of the left incisor lobe of *P. f. laetifica* is made up of four distinct, sharp, pointed denticles instead of three. These features are easily observed in an anterior-ventral view of the left mandible. The molar areas of the mandibles are proportionally larger among these ligneous feeders. For the genus *Pterophylla*, Hebard (1941) records five species and subspecies, each occupying its own territory but covering essentially all of the deciduous forest areas of the eastern half of the United States where oaks are found. The sedentary habits of the *Pterophylla* are well known. Many individuals, doubtless, spend their entire life on the same tree where they were hatched. It is possible that colonies may be maintained from year to year on isolated large oak trees. This implies a monophagous feeding behavior. Cage tests would probably show that for optimum longevity and fecundity oak leaves are necessary to the maintenance of the various species of *Pterophylla*.



The jaw pattern of *Microcentrum rhombifolium* (Sauss.) is of special interest. While this species is placed in the subfamily Phaneropterinae, its mandible structure is more like that of *P. f. laetitia*, one of the Pseudophyllinae. When one finds that *M. rhombifolium* is also an arboreal katydid feeding on the leaves of oaks and other trees (Riley, 1874, p. 158), we see again that food is the determining factor in explaining similarity in mandible patterns rather than actual or perhaps supposed taxonomic relationship.

### Corpiphorinae, Conocephalinae, Decticinae

The species of these three subfamilies have mandibles which are different in morphology from those previously described. While individually distinctive, as far as the species examined are concerned, the mandibles of all the members of the three subfamilies have a similar fundamental jaw pattern. The dorso-ventral or the proximal-distal axes of the mandibles are definitely elongated (fig. 4) and the lateral

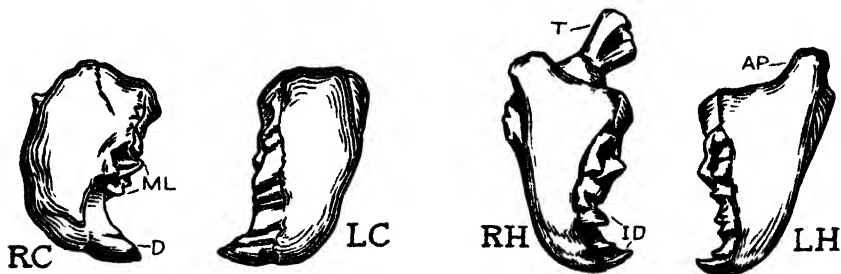


FIGURE 4 Seminivorous mandibles of *Neoconocephalus robustus crepitans* Scud. (RC and LC), and carnivorous mandibles of *Pediodectes haldemani* Girard (RH and LH).

RC and LC, anterior-ventral views of mandibles of *crepitans*. The right mandible (RC) is turned out slightly so as to better show molar lobe. The incisor dentes are fused forming the single dens (D). RH and LH, anterior-ventral-mesial view of mandibles of *haldemani*. The mandibles are turned out slightly from anterior view. AP, anterior articular process; ID, incisor dens; IL, incisor lobes; ML, molar lobes; T, tendon.

axes are proportionally narrower than the corresponding parts of the mandibles of the other Tettigoniidae and Acrididae heretofore considered. This greater dorso-ventral length is chiefly the result of a distal extension of the basal portion of the mandibles thus giving a handle, as it were, for reaching and grasping, especially by the apical incisors.

**Seminivorous Mandibles.**—The food preference tests of representative Corpiphorinae were not undertaken until the summer of 1941. Preliminary cage testing, described below, proved that the two available species, *Neoconocephalus robustus crepitans* Scud. and *N. tripus* L., were chiefly seed eaters and that they have distinctive mandibles.

In these species the distal incisor lobes are extended into a narrow chisel-shaped single dens, which results in an elongation of the dorso-ventral axes of both mandibles and reminds one of rodent incisor specialization. These incisor dentes overlap, left to right, ventrally.

The molar areas are tuberculose and not extensive. Such rodent-like incisor teeth would appear to be well suited to the shelling of seeds from the spikelets of grasses, (fig. 4, RC and LC).

In April, 1941, a few specimens of over-wintering *N. triops* were caged for behavior study. They refused to eat a wide assortment of vegetation provided as food and ultimately starved. On July 19, 1941, eleven specimens of a new generation of *N. triops* and fourteen individuals of *N. r. crepilans* were caged separately in a second attempt to discover the diet of these cone-heads. In their natural habitat they are always associated with tall grasses. Accordingly, their cages were supplied with a wide range of grasses and forbs from their optimum habitats. Since their vicious biting, when taken in the field, suggested that possibly these nocturnal long-horns were carnivorous, various insects were also placed in the cages. Among the insects were nemobid crickets, leafhoppers, flies, nymphs of acridians and meadow grasshoppers. A day by day count indicated that the insects offered as food were unmolested. There was some slight nibbling on stems and fruits pods of forbs. At night the neoconocephalans seemed to be hunting for food on the floor of the cages, but in the main, a hunger strike prevailed. Leaves of forbs, grasses, insects—all were unacceptable even as starvation rations. After three days' experimentation, almost by chance, seed-bearing shoots of green grasses were put into the bottles which held other fresh vegetation. Observation after dark showed at once that the hunger strike was over, as all individuals in both cages were eagerly feeding on the seeds in the spikelets of the grasses. Examination in the morning showed the grass seed-heads riddled. Among the grasses in fruit supplied were the following, which are listed in order of apparent preference: *Setaria viridis* (L.) Beauv., foxtail; *Panicum helleri*, Nash, wild rice; *Paspalum dilatatum* Poir., Dallas grass; *Echinochloa colonum* (L.) Pers.; *Sorghum halpense* (L.) Pers., Johnson grass. Forbs in the fruit were also supplied; among these were *Melalotus*, *Lepidum*, and *Gailardia*. These were not eaten but the grasses were riddled. Johnson grass fruit heads seemed to be the least preferred among the grasses offered, although under present conditions in north-central Texas, this appears to be the most available and abundant food plant where optimum populations of these two species are located by night-time stridulatory evidence.

The diurnal behavior of these Corpiphorinae is of interest. Many nocturnal Tettigoniidae, when confined in cages, show considerable activity during the day, which varies with the species concerned. These cone-heads, however, were passive during the daytime and as a rule hung head down among the shoots of the vegetation in the cages; after dark their activity was resumed. In the field, active stridulation is usually delayed for about thirty minutes after dusk.

**Carnivorous Mandibles.**—Two species of the Decticinae, *Pediodes haldemanii* Girard and *P. nigromarginatus* (Caudell), were rather extensively cage tested (Isely, 1941a) as to their feeding behavior and were found to be "wholly carnivorous."

The mandibles of *P. haldemanii* are selected as representative of the carnivorous jaw model (fig. 4, RH and LH). The dorso-ventral axes are definitely elongated; the grinding surfaces of the molar lobes are much

reduced. The three incisor dentes are somewhat fused and distally extended to form a cutting and grasping hook. The parallel with carnivorous mammal jaws is further emphasized as one studies the structure of the tiger-like biting mandibles of these Decticinae. In addition to *P. haldemanii*, the mandibles of four other species were examined, *Rehnia cerebrus* R and H, *Pediodes nigrumarginalis* (Caudell), *P. stevensonii* (Thos.), and *Anabrus simplex* Haldeman.

All of these have typically carnivorous mandibles. Further cage testing would probably show that North American Decticinae are chiefly carnivorous rather than "primarily herbivorous" as suggested by Caudell (1907). Fabre found the European "White-faced Decticus" to be predaceous. Burr, Campbell, and Uvarov (1923) report several Macedonian Decticinae to be "fierce carnivora." The notorious Mormon cricket, *Anabrus simplex* Haldeman, supplies a striking exception by its omnivorous feeding activities. No North American grasshopper has been more critically checked and observed in field and laboratory by economic entomologists. Swain (1940), after intensive field work, reports four hundred and sixty plant species which *Anabrus* definitely attacks and damages. Cowan (1929) finds that *Anabrus* is not only polyphagous but predaceous, cannibalistic, and especially adept at shelling all the grains found in seed heads of cereal crops. Its mandibles are similar to those of *Pediodes haldemanii* though proportionally somewhat less elongated. However, only a small series was examined. In *Anabrus*, then, we have a species which is seminivorous, carnivorous, forbivorous, and graminivorous. An indiscriminate taste and greed for all organic stuff appears to be the best explanation for the omnivorous feeding behavior of *A. simplex* and *Peranabrus scabricollis* Thos., two Decticinae which are economic species of prime importance in the western United States.

The writer's observations of *Anabrus* have been limited to a few weeks of field study in the area of the Rocky Mountain Biological Laboratory, Gothic, Colorado, (July-August, 1932). The brief review of its feeding behavior, summarized above, is based on the reports of several investigators of the Mormon cricket.

*Carnivorous-seminivorous Mandibles.*—Only a short time was given to cage investigations of the food preferences of the Conocephalinae (September-October, 1941). The following species of the Conocephalinae were checked for their feeding activities: *Orchelimum vulgare* Harris, *O. silvaticum* McNeill, *O. nigripes* Scud., *Conocephalus fasciatus* (DeGeer), and *C. striclus* (Scud.).

These observations indicate that the five species tested vary considerably in their feeding behavior. In cage experiments with these alert and timid grasshoppers, it was difficult to observe instances of the active capture of insects as was easily done in the case of the Decticinae. The other insects placed in Conocephaline cages were, however, consistently reduced in numbers and occasional observations were made of contact and capture between predator and prey. The shelling of grass seed heads and the eating of grass seeds showed a feeding behavior similar to that of the cone-heads. The feeding on the leaves of forbs and grasses was exceedingly meager. Starvation tests, which were only preliminary, appeared to indicate that the Conocephalinae would nibble on grasses

and grass stems under starvation pressure. Under these conditions they would live for a considerable period, but it was clearly indicated that although the leaves and stems of grasses were unpalatable, grass seeds were eaten with avidity. In view of this feeding behavior of the Conocephalinae, their mandibles are tentatively designated as carnivorous-semivivorous, though in all five species examined, the mandibles are essentially carnivorous in pattern. The mandibles of *O. vulgure* are figured by Yuasa (1920, pl. 4, figs. 79 and 82). Study of the feeding behavior and jaw structure of the various species of the Tettigoniidae reveals an entire absence of graminivorous mandibles and the almost complete refusal of the leaves of grasses for food.

## DISCUSSION

*Biological Implications.*—The close correlation of the structure of mandibles and the food preferences of grasshoppers is a further confirmation of species adjustments to a wide ranging variation in available food. The striking parallelism shown in the morphology of the mandibles of grasshoppers and mammals, as a result of similar adaptations to varying plant tissues and animal food, is just another impressive exemplification of convergent evolution.

Further study of mandibular morphology, coupled with food testing, should contribute to an understanding of orthopteran ecology and help to evaluate the factors which play the important roles in terrestrial communities. From the viewpoint of ecology it is evident that all experimental data dealing with food specificity of grasshoppers thoroughly support the claim that grasshopper species are just as perfectly synchronized to the niches of their species activity and to their microhabitats as are organisms in general. The availability of specific host plants, contrary to the conclusions of Urquhart (1941, p. 79), looms large as one of the important environmental factors in evaluating conditions which will help explain the local and regional distribution of grasshoppers.

An understanding of mandibular morphology will afford economic entomologists clues which will enable them to forecast with more assurance the possible hazards to crops and range from shifting populations of waste land and desert grasshoppers.

The conviction that all of the hundreds of different species of grasshoppers eat everything green, and especially grass, is no longer tenable. These investigations show that many of the species which have been cage tested are more frequently beneficial than harmful because their host plants which they hold in check are competitors of range grasses.

Economic entomologists working on the problem of the control of pest species with highly potent baits (Shotwell, 1942) should also investigate the possibility of the eradication of primary host plants as a method of cutting down the longevity and fecundity of certain oligophagous pest species, e. g., *Melanoplus bivitatus* and *M. differentialis*. Food specificity experiments already under way (Pfadt and Fritz) should be vigorously prosecuted for all economic species.

The taxonomist and the evolutionist will find in structure and variations of mandibles an aid to orthopteran classification and to species differentiation and possibly some clues to speciation.

*Grasshoppers and Vegetation.*—Many acridians are irrevocably associated with the Gramineae for food, shelter, and sod or grass roots in which to deposit their eggs. Field and laboratory observations make it clear that most of the Acridinae have graminivorous mandibles and become adapted in body form and color to the stems or leaves of the grasses of their microhabitats. Feeding tests definitely indicate that for these graminivorous species, grass diets are necessary. Certain of the long-horns use grass leaves and spaces between the leaves as repositories for their eggs. Other tettigoniids appeared to relish and feed with avidity on grass seeds. Tettigoniidae tested in cages refused or only slightly nibbled the blades or stems of grasses, even under starvation pressure.

While certain acridians are wholly graminivorous, it is evident from field and experimental data that other grasshopper species, genera, and subfamilies are just as definitely associated with forbs. Here belong the Cyrtacanthacrinae, Phaneropterinae, and certain other non-graminaceous groups. Several forbivorous species are essentially monophagous. While not necessarily limited to a single host plant, a number of species belonging to the north-central Texas grasshopper fauna live very successfully and appear to secure all diet needs for their longevity and reproductivity while feeding on a single host plant. In the field these species are found in maximum populations either on or in close proximity to the plant species which cage tests have shown to be their host plant or first choice food plant in the area under observation. Many of these grasshoppers, whether monophagous or restricted oligophagous species, strikingly harmonize in body form and color with the host plant leaves or stems which serve as their backgrounds. These species not only feed on forbs but have forbivorous mandibles. Carnivorous tettigoniids are usually nocturnal and use plants chiefly for roosting and cover. The same plants may supply food and shelter for their insect prey.

*Food Specificity Analyzed.*—Food preference and maintenance diet experiments previously cited and discussed in this paper point to but one conclusion; grasshoppers, in common with all organisms from bacteria to man whose diet requirements have been critically tested, demand for health, longevity, and reproductivity, an adequately balanced diet.

Food specificity for insects in general, is well established. Only four representative researches will be cited here: Glaser (1923), D. Isely (1928), Brues (1940), and Painter (1941). The idea of food specificity in grasshoppers was experimentally demonstrated by Riley (1874) seventy years ago. Even economic acridians, which destroy nearly all crops, need specific foods (Hodge, 1933, and Sanderson, 1939).

All of the North American Acrididae are phytophagous. In cages many species will eat the dead bodies of other acridians even when supplied with their preferred plant food. No short-horned grasshopper, however, even under starvation pressure has shown any predatory tendencies in the writer's cages beyond the eating of antennae of weaker neighbors.

*Mandible Patterns.*—Four chief mandible models are shown by southwestern and western United States grasshoppers (Acrididae and

Tettigoniidae) which adapt the different groups, chiefly subfamilies, for wide-ranging diet possibilities. Besides the four major models, four combination models have been evolved, making a total of eight.

Representative species have been discussed which exemplify the basic and combination models as follows: (1) forbivorous mandibles are found largely among the Cyrtacanthacrinae, Romaleinae, many Oedipodinae, and a very few Acridinae; (2) graminivorous models are characteristic of the Acridinae, many Oedipodinae, and a very few Cyrtacanthacrinae; (3) carnivorous jaws are shown by the Decticinae; (4) semivivorous mandibles are most clearly seen in the special pattern of the seed-eating Corpiphorinae.

The combination patterns are less easily defined but show interesting variations: (5) herbivorous mandibles belong to the mixed feeders, especially the notorious pest grasshoppers *Camnula pellucida* (Oedipodinae), *Melanoplus mexicanus* (Cyrtacanthacrinae), *et al.*; (6) florivorous-forbivorous mandibles include most of the Phaneropterinae; (7) lignivorous jaws seem to have reached only generic group differentiation and are represented by *Pterophylla* and *Microcentrum* (Tettigoniidae) and by several *Schistocerca* (Acrididae) which may be included here rather than in the forbivorous grouping above; (8) semivivorous-carnivorous species, represented by the Conocephalinae, are here separated from other Tettigoniidae on account of their feeding behavior and no distinctive jaw pattern has been determined. Their mandibles are essentially carnivorous, but feeding activities suggest that further study may justify their separation from the more strictly carnivorous decticids. The omnivorous feeding behavior of *Anabrus simplex* would appear to demand a separate group, but here, as in (8), the pattern is carnivorous.

The above groupings represent only a small segment of the worldwide order Orthoptera and it should be evident that these groupings must be viewed as tentative and provisional. Since grasshopper mandible patterns, however, follow lines of specialization characteristic of the chewing mechanisms of all kinds of animals the biological soundness for these mandible models as here characterized would appear to be substantiated.

The mandibular patterns of these southwestern United States grasshoppers will doubtless be found to be representative of many species of the Acrididae and Tettigoniidae in all parts of the world.

### SUMMARY

1. Of 89 Acrididae examined, 34 had graminivorous, 37 forbivorous, and 18 herbivorous mandibles.

2. Among the 24 Tettigoniidae studied, 10 had florivorous-forbivorous, 2 lignivorous, 2 semivivorous, 5 carnivorous, and 5 semivivorous-carnivorous mandibles.

3. Morphologically, mandibles are definitely correlated with food, but in the main, mandible patterns follow genetic lines. Strangely enough, certain of the species which have broken away from usual subfamily feeding behavior are also quite dissimilar in structure from typical subfamily representatives as characterized by taxonomists, *e. g.*, *Acrolophius variegatus* (Acridinae), *Leptisma marginicollis* (Cyrtacanthacrinae), *et al.*

4. Variations in mandible structure within a species are especially marked among the mixed feeders.

5. Food specificity appears to offer tangible clues toward a better understanding of grasshopper communities and the interrelationships between these Orthoptera and plants.

6. It should be evident that food specificity research will contribute to further progress in working out the control of pest hoppers.

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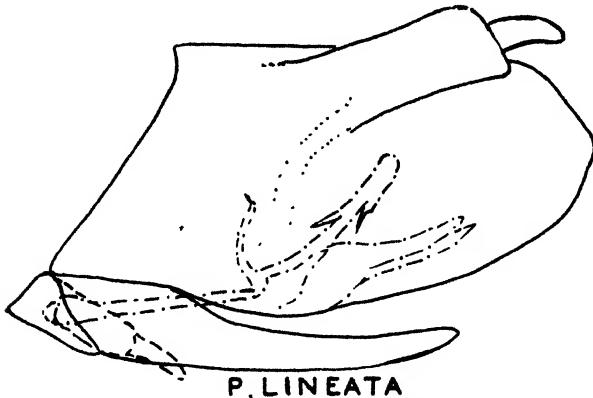
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## A NEW SPECIES OF PLUMMERELLA (HOMOPTERA, CICADELLIDAE) FROM MEXICO

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The genus *Plummerella* was recently described by the writer (Ann. Ent. Soc. Amer., 35: 200, 1942) to include a species *alpina* which has been found only at high altitudes in the mountains near Mexico City. Another species not available for study at the time *alpina* was described is being described at this time from specimens collected at a lower altitude, some 200 miles west of Mexico City. *P. alpina* occurs in the tall clumps of bunch grasses which are common in the pine and fir forests at some 10,000 feet elevation. *P. lineata* occurs on the tall grasses growing in the oak-pine forests at an elevation of some 7500 feet. They are closely related but may be distinguished by their coloration, shape and by the male genital structures.



*P. lineata*, lateral view of male genital structures.

### **Plummerella lineata** n. sp.

In form and general appearance resembling *alpina* but more narrow and elongate, different in color and with different male genitalia. Length, male, 7 mm.

Vertex elongate, convex on dorsal surface, one and one-half times as long as basal width between eyes. Ocelli about one-fifth the distance from base to apex which is bluntly pointed.

*Color*.—Pale yellow with dark markings. Vertex with a pair of median, proximal parallel lines arising at apex and extending almost to base. Each line is broadened not far from apex and gives rise on the outer margin to an oblique line which extends almost half-way to base and is parallel to the outer margin. Just anterior to the ocelli,

a short oblique spur arises on the outer margin of each parallel line. Pronotum with the lateral margins dark brown and four prominent brown marks on median anterior half. Scutellum with three short longitudinal parallel brown lines on anterior half, the median line terminating in a transverse brown dash on middle. Elytra rather bright yellow, a broad brown longitudinal stripe just above costa and parallel to it. Pale brownish diagonal stripes are on the clavus and the inner apical margin is brownish subhyaline.

*Genitalia.* -Male plates narrow, elongate, triangular, the apices rolled and divergent. Pygofer more than one-third longer than plates. Styles slightly more than one-third as long as plates, rather narrow, the apical half deeply concavely excavated on outer margin forming a long curved, finger-like process with a pointed apex. Aedeagus composed of several parts as in *alpina*. The anterior process extends erect from the base. Caudad to this is a rounded, elongate process, extending dorso-caudally and with a ring of spines extending basally just beyond a constriction at about its middle. The posterior-basal structure is cleft on posterior half, forming a pair of narrowed apical pieces which are attached to a broader basal portion.

Holotype male and paratype male collected from tall grass in the oak forest association at Carapan, Mich., Mexico, 7500 feet elevation, October 2, 1941, (Km. 432) by C. C. Plummer, J. S. Caldwell, E. E. Good and the author

TYROGLYPHID MITES IN STORED PRODUCTS I. A SURVEY OF PUBLISHED INFORMATION, by M. E. SOLOMON. Pages iv+36, 5 figures, 6 x 9½ inches, paper bound. Published by HIS MAJESTY'S STATIONERY OFFICE, London. Price, 9d.

The broad scope of this paper is indicated by the table of contents: 1, Introduction; 2, Systematics; 3, Morphology and Internal Anatomy; 4, Biology (life history, nutrition, and behavior); 5, Bio-ecology (occurrence, means of distribution, parasitism, medical and veterinary significance, and natural enemies); 6, Physical Ecology (effects of temperature and humidity); 7, Tyroglyphids in Stored Products, and their Control (pp. 13-22); 8, Discussion; 9, References (pp. 25-36).

The information presented in this paper has been accumulated during three years of work on tyroglyphid mites. This work is a part of the research program of the Department of Scientific and Industrial Research on the infestation of stored products by insects and allied pests. The tyroglyphid mites are of common occurrence in stored products, where they may cause considerable damage. The literature on these mites, while extensive, is scattered, and this paper presents a summary of the published information which will serve as a guide for use by those concerned with the study and control of these pests.

In his "Discussion" the author draws three principal conclusions: (1) Moisture plays the dominant role in the ecology of the tyroglyphids, and therefore the provision of sound, dry storage conditions is of first importance. (2) There is a need for quantitative data on the rate of increase and the direct and indirect damage done under various storage conditions, the physical aspects of which should be dealt with quantitatively. (3) More critical work on control measures is needed, with attention given to the special resistance of the hypopus and egg stages.—D. J. B.

# ENVIRONMENTAL CONTAMINATION BY AN INSECT PARASITE AND THE EFFECT ON HOST SELECTION<sup>1</sup>

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One of the most interesting factors affecting host selection, or host suitability (which term is used depends upon the viewpoint), is that of host "conditioning," as reported by Salt (1937) for *Trichogramma*. *Trichogramma* females so contaminate eggs of their host, *Sitotroga*, by walking over them, that the eggs may not be acceptable to other females. This phenomenon is apparently caused by a water-soluble substance secreted by certain tarsal glands of the females examining or walking over the host eggs.

The present paper deals with a somewhat similar phenomenon, discovered during investigations with populations of the housefly, *Musca domestica* L., and its pupal parasite, *Mormoniella vitripennis* (Walker). This phenomenon, however, concerns contamination of the experimental environment, or habitat, so that a normal host, even though found, may not be successfully parasitized.

The experimental environment of the present tests was similar to that described in detail in an earlier paper (De Bach and Smith, 1941, p. 365). Ten-gallon tins having tight, insect-proof lids and containing either 2 or 6 quarts of barley were used. Puparia of the host (*Musca domestica*) were distributed through the grain, through which the parasites (*Mormoniella vitripennis*) crawled in search of their hosts.

In the course of the necessary preliminary work with the experimental universe that was developed during the population studies mentioned above (De Bach and Smith, 1941), a change in per cent parasitization took place so gradually that it was not noticed until parasitization dropped to a very low point. When the drop in parasitization was first noticed, difficulty in searching for hosts was thought to be the cause. In August, 1939, the number of hosts used in experimental tests was therefore doubled, to lessen the supposed difficulty in searching. Despite this advantage in favor of increased parasitization, a large part of these tests showed no parasitism whatever. A fair number of the hosts had been "stung,"<sup>2</sup> but practically no eggs had been deposited by the parasites.

These puzzling results led to a compilation of the experimental data for several preceding months; this revealed that there had been a steady decline in amount of parasitization in tests thought to be exact replications. (See Table I.) Even after the host density was doubled and the amount of barley was reduced, from 6 quarts to 2 quarts, later

<sup>1</sup>Paper No. 504, University of California Citrus Experiment Station, Riverside, California.

<sup>2</sup>Hosts that have been "stung" have been killed by the insertion of the parasite's ovipositor, either in feeding or egg-laying.

in August, parasitism remained practically nil (Table II). Tests were immediately begun to determine the cause of the decline.

Various miscellaneous trials were unsuccessful. Then recollection of Salt's (1937) report on host-conditioning in the case of *Trichogramma*, previously mentioned, led to the thought that perhaps the housefly

TABLE I

DECLINE IN PERCENTAGE OF PARASITIZATION OVER A FOUR-MONTH PERIOD IN 1939, IN TESTS IN WHICH PARASITES (*Mormoniella vitripennis*) SEARCHED FOR THE PUPARIA OF THEIR HOST (*Musca domestica*) THROUGH 6 QUARTS OF BARLEY GRADUALLY CONTAMINATED BY REPEATED USE.\*

DATE	EXPERIMENTAL TESTS					CONTROL TESTS (No Barley)
	Number of Replications	Total Number of Parasites	Total Number of Hosts	Hosts Parasitized		Per Cent Parasitization
				Number	Per Cent	
May...	6	180	180	44	24.4	61.7
June...	18	540	540	41	7.6	63.0
July	8	240	240	13	5.4	52.5
August...	12	380	760	7	0.9	51.7

\*Except in August, when the host density was increased, 30 parasites and 30 housefly puparia were used in all tests.

TABLE II

THE EFFECT OF CONTAMINATED BARLEY\* ON PARASITIZATION, IN TESTS IN WHICH 40 PARASITES SEARCHED THROUGH 2 QUARTS OF GRAIN FOR 80 HOST PUPARIA.

Test	Total Number of Hosts Stung	Total Number of Hosts Parasitized	Percentage of Hosts Parasitized
1.....	33	0	0.00
2.....	50	1	1.25
Control (no barley)...	62	37	46.25

\*The barley has been used repeatedly in previous tests and was used in these tests without cleaning.

parasites were in some way contaminating the barley by running over it in the course of their search for their host, so that, after a time, oviposition was inhibited. There was also a possibility that the condition might be due to continued contact of the puparia with the barley, or to the fact that the experimental tins had not been cleaned after use in preceding tests. Experiments were designed to test these hypotheses.

In these experiments 40 *Mormoniella* searched for 80 puparia through 2 quarts of barley, either new, washed in water, or contaminated by use in previous experiments. The tins were either clean or contaminated (previously used). The results of the experiments, presented in Table III, show clearly that contaminated barley is the sole factor affecting parasitization, and that contaminated barley which has been washed in water and dried is just as good as new grain for experimental purposes. For experiments 1 to 5, inclusive, chi square is 39.6, showing a high probability that these experiments *are not* homogeneous; for experiments 1 to 4, inclusive, chi square is 1.25, showing a high probability that these experiments *are* homogeneous. We may therefore assume that the two types of tins and two types of grain in experiments 1 to 4 show no significant differences, and that the difference in per cent parasitization between the groups 1 to 4, inclusive, and number 5 is due solely to contaminated barley.

TABLE III

EFFECT OF CLEAN OR CONTAMINATED (PREVIOUSLY USED) BARLEY AND CONTAINER ON PARASITIZATION, IN TESTS IN WHICH 40 PARASITES SEARCHED THROUGH 2 QUARTS OF GRAIN FOR 80 HOST PUPARIA.

Test	Experimental Setup	Number of Hosts Parasitized	Percentage of Hosts Parasitized
1	New barley in clean tin. . . . .	26	32 50
2	New barley in contaminated tin. . . . .	31	38 75
3*	Washed† barley in clean tin. . . . .	26	34 66
4	Washed† barley in contaminated tin. . . . .	32	40 00
5	Contaminated barley in contaminated tin. . . . .	1	1 25

\*In this test only 75 host puparia were used.

†Washed in water.

Observations indicate that barley is contaminated when numerous parasites have run over the grain. This conditioning could, however, be due to the fact that many puparia have been mixed with the grain, with the result that the host-odor stimulus is so great as to cause females to be unable to distinguish readily between barley grains and true hosts, and therefore to cause them to attempt oviposition in the barley grains.

A phenomenon of this sort has been discussed by Ulyett (1936, p. 260-261) in his analysis of Salt's (1935) work with *Trichogramma*, on host selection. *Trichogramma*, according to Salt, selected particles of sand when host eggs were equally available, because the females preferred the larger size of the false hosts. Ulyett, on the other hand, holds that "any 'attack' on the sand grain . . . might be attributable to this (host-odor) stimulus and not to any actual preference for the sand-grain on account of size alone." In connection with the present experiments, however, preliminary tests, in which ground host puparia were mixed with the grain in order to lessen the odor-stimulus of the host to the searching parasites, showed no appreciable reduction in parasitization.

Evidence shows that the effect of contaminated grain is to keep the parasites from depositing their eggs. They apparently find and sting approximately half as many hosts as they would in clean barley. Thus, while the percentage of parasitization varies strikingly in tests with clean and contaminated barley, the percentage of hosts stung in these tests, varies much less. Although contamination of the barley is probably caused by tarsal secretions of the insect, the actual mechanism of the contaminated grain and its exact effect on the parasite, remain to be worked out.

## DISCUSSION

The process of parasitization may be considered as divided into three phases: (1) host-finding, (2) host selection, and (3) host suitability. Host-finding consists in the finding of the environment containing the host and the finding of the host within the environment.

While the environment-finding procedure is still obscure, it is, in most cases, certainly not haphazard; rather, it must be very similar to the host-finding—host-selection—host-suitability complex. The processes involved may therefore be classified similarly into (1) environment-finding, (2) environment-selection, and (3) environment-suitability.

Environment-finding and environment-selection are probably similar, in general, to host-finding and host selection. Several authors have recognized the important part played by the environment in influencing these two phases of parasitization. Salt (1935, p. 414) states that:

"Now it is certain that some parasites, and probable that many more, are first attracted not to a particular host but to a certain type of environment. By selecting a particular environment in which to search for hosts, and neglecting other places, the parasite restricts the number of potential host-species that it will meet, and so limits the number of species on its list of hosts. This, if it is host selection at all, might be distinguished as an oecological selection of hosts."

Flanders (1937) has found that environmental selection operates in the genus *Trichogramma* in such a way as to cause the species *evanescens*, *embryophagum*, and *semlidis* to occur in different habitats, even though hosts suitable for each species occur in all habitats.

Laing (1937) has reviewed the literature on cases of parasites searching, first, for a certain environment, and then for the host within the environment, and has concluded that many parasites "when they search for hosts, appear to find first a particular type of environment, and then proceed to seek the hosts themselves." Laing has also demonstrated experimentally that *Alysia manducator* and *Mormoniella vitripennis* are attracted to an environment likely to contain their hosts, by qualities of the environment itself, independent of the presence of hosts. Environmental suitability has not been discussed, as such, either by the workers named above or by any others with whose work the writer is familiar. Once the host has been found, the environment has been assumed to have little or no further effect on the parasite; the selection of the host has, thus far, usually been shown to depend on the qualities of the host itself. The present case of environmental unsuitability, in which the contaminated environment renders the host

unsuitable for parasitism, is apparently unique. Obviously, environmental suitability may be of the utmost importance, especially in laboratory studies; and its effect, if any, should be considered and investigated in all highly accurate studies. Ulyett says (1936, p. 264):

"We have yet to define and determine the effects of abnormal environments. It seems not unlikely that the majority of our laboratory experiments, however closely they appear to conform to what we consider optimum conditions for the insect subject, may contain some abnormal element of which we know nothing but which, nevertheless, duly affects the delicate organism with which we are dealing."

### SUMMARY

*Mormoniella vitripennis* (Walker), a pupal parasite of the housefly, *Musca domestica* L., was used in tests in which the environment consisted of fly puparia dispersed through barley grains. The parasites so contaminate the grain by running over it in their search for their hosts that eventually no parasitization is obtained in tests in which this grain is used. When contaminated grain was cleaned with water and used in other tests, normal parasitization was obtained.

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## NOTES ON AGRILUS WITH DESCRIPTIONS OF TWO NEW SPECIES

(Buprestidae: Coleoptera)

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It is the idea in this paper to figure the male genitalia of the North American species of *Agrilus* not illustrated to date. Since the *Agrili* are quite selective as to host, records of capture may lead to a more definite establishment of plants in which the species breed.

### *Agrilus cavifrons* Water.

Figure 6

Waterhouse, Biol. Centr.-Amer., Coleopt., vol. 3, pt. 1, p. 189, 1899; Knull, Ohio Jour. Sci., 37(5): 305, 1937.

*Male*.—Form strongly cuneiform, bronzy brown above, cupreous beneath; pubescence of elytra forming an irregular design.

Head with a broad deep depression covering the entire front, the concavity containing five small smooth depressions arranged in a circle; surface of vertex coarsely punctured, front clothed with short pubescence obscuring surface; antennae extending past middle of pronotum when laid along margin, serrate from the fourth segment.

Pronotum wider at base than at apex, widest at middle; sides broadly rounded in front, sinuate at base; when viewed from the side, marginal and submarginal carinae joined back of middle; anterior margin strongly sinuate, median lobe broadly rounded; base strongly emarginate at middle of each elytron, median lobe truncate in front of scutellum; disk with broad deep triangular depression, widest in rear, a deep lateral depression each side, prehumeral carinae short, well indicated; surface irregularly coarsely punctured, finely granulose area in front of scutellum, depressions with short pubescence. Scutellum finely granulose, transversely carinate.

Elytra wider than base of pronotum, widest near base; sides strongly constricted back of base, expanded back of middle, obliquely narrowed, sinuate near obtusely rounded apices, apices serrulate, disk convex, basal depressions deep, each elytron with a strong, smooth, sinuate longitudinal costa which extends from humerus to apex, another short straight costa on outside back of middle; surface coarsely irregularly punctured.

Abdomen beneath irregularly punctured; last ventral with longitudinal carina, carina not projecting, a depression each side at apex; first two ventrals strongly convex, not flattened. Prosternal lobe strongly declivous, anterior margin broadly rounded. Anterior and middle tibiae arcuate, mucronate on inner margin at apices; posterior tibiae straight, not mucronate. Posterior tarsi only slightly shorter



than tibiae. Tarsal claws cleft near tip on anterior pair of legs, cleft deeper on second pair and deepest on posterior pair, inner tooth not turned inward.

Length 10.5 mm.; width 3 mm.

*Female*.—Differs from male by apical spines of first two pairs of tibiae being very short.

According to Fisher's key<sup>1</sup> the species would run to *A. lucanus* Fall. It can be separated by the carinate last ventral abdominal segment.

Since I recorded this species as occurring in our fauna, Dr. K. G. Blair kindly compared a specimen with the type in the British Museum. Specimens were collected on desert hackberry (*Celtis pallida* Torr.), the host plant, in the Santa Catalina Mts., Santa Rita Mts. and at Florence, Ariz., in Aug. and Sept.

### ***Agrilus palmerleei* n. sp.**

Figure 3

*Male*.—Robust, elongate; head and pronotum brilliant cupreous; elytra piceous; ventral surface and legs cupreous.

Head with longitudinal groove extending from occiput to middle of front; surface coarsely punctate becoming rugose on occiput, pubescence inconspicuous; antennae not reaching middle of pronotum when laid along side margins, serrate from the fourth segment.

Pronotum wider than long, base and apex of about equal width, widest in front of middle; sides broadly rounded in front, sinuate near base; when viewed from the side, marginal and submarginal carinae joined at base; anterior margin nearly straight; basal margin emarginate at middle of each elytron, median lobe truncate in front of scutellum; disk convex, with two median depressions, a strong oblique lateral depression on each side, prehumeral carinae short; surface transversely reticulate, pubescence inconspicuous in all but lateral depressions. Scutellum transversely carinate.

Elytra at base wider than base of pronotum; sides expanded at base, constricted in front of middle, widened back of middle, then gradually narrowed to rounded apices, margins serrulate back of middle; disk flattened, each elytron with a longitudinal costa extending from near basal depression to near apex; surface finely imbricate, pubescence inconspicuous.

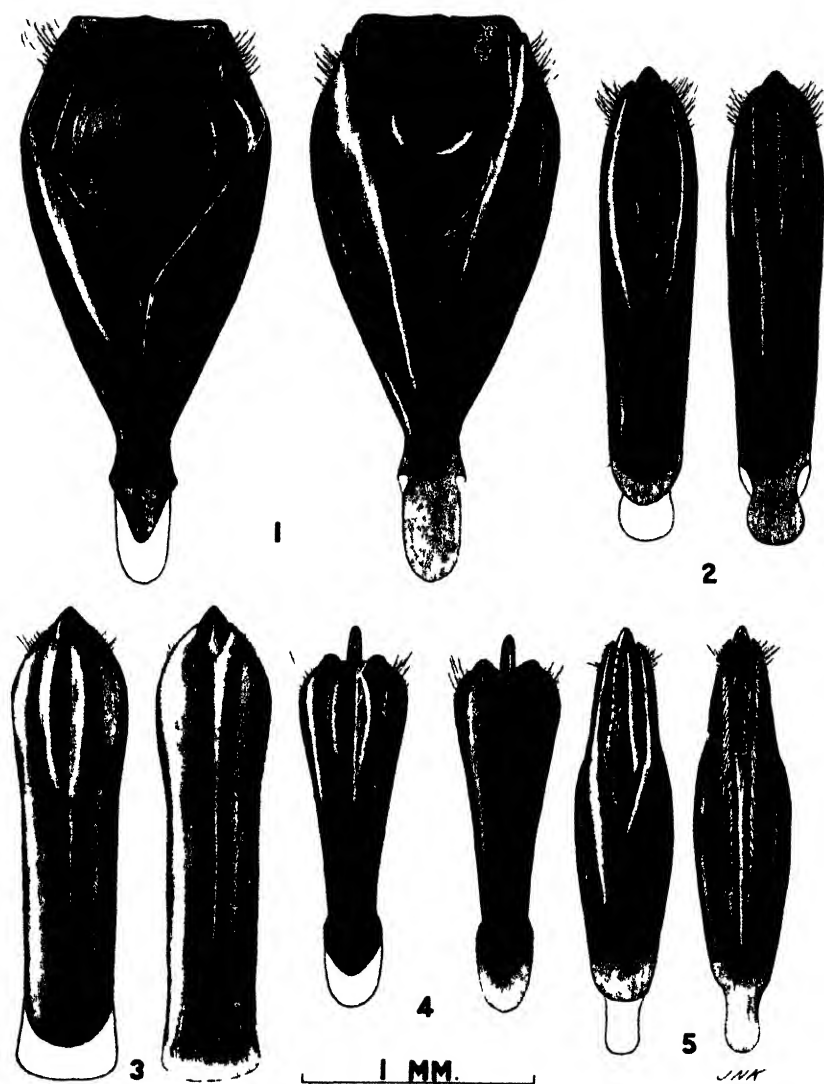
Abdomen beneath finely granulose, pubescence very short; first two segments convex at middle, not modified; pygidium without projecting carina. Prosternum pubescent, pubescence not extending along median ventral area; prosternal lobe broad, strongly emarginate in front; prosternal process with sides parallel to behind coxal cav-

<sup>1</sup>W. S. Fisher, U. S. National Mus. Bul. 145, pp. 1-347, 1928.

### EXPLANATION OF PLATE I

Male genitalia of *Agrilus*; the figure on the left represents the dorsal surface, and the one on the right represents the ventral area.

FIGURE 1, *snowi* Fall; 2, *lucanus* Fall; 3, *palmerleei* n. sp.; 4, *townsendi* Schffr.; 5, *limpiae* Knull.



ities, then acutely narrowed to apex. Tibiae on first two pairs of legs mucronate on inner margin at apex. Posterior tarsi shorter than tibiae, first segment about as long as following segments together. Tarsal claws similar on all feet, cleft near middle, inner tooth nearly as long as outer one and not turned inward, tips distant.

Length 9.5 mm.; width 2.4 mm.

Holotype male described from a specimen in the collection of the writer labeled Huachuca Mountains, Ariz., July 15, 1937, D. J. & J. N. Knull collectors. This species runs to *A. townsendi* Fall in Fisher's key. It can be distinguished by being more elongate, elytra less evidently pubescent, pronotum proportionately longer, prehumeral carinae joining at base, structure of the posterior tarsi and form of genitalia.

#### ***Agrilus fuscipennis* Gory**

Adults were taken on persimmon (*Diospyros virginiana* Linn.) foliage at Otway and Shawnee State Forest, Ohio, June 8-10, 1943; these are the most northern records to date.

#### ***Agrilus cliftoni* Knull**

On June 28, another specimen of this species was collected along Clear Creek, Hocking Co., Ohio. A closer examination shows that all tibiae are mucronate on inner sides at apices. This would place the species next to *A. geminatus* (Say) according to Fisher's key.

#### ***Agrilus snowi* Fall**

Figure 1

Specimens of this rare species were collected on palo verde (*Parkinsonia microphylla* Torr.) at Globe, Ariz., Sept. 9, 1941, by Mr. F. H. Parker.

#### ***Agrilus costipennis* Fisher**

Collected from the foliage of hackberry (*Celtis mississippiensis* var. *reticulata* Sarg.) in the Davis Mts., Tex., from June 19 to July 5. It was collected also in the Chisos Mts., Tex., July 9 and the Chiricahua Mts., Ariz., June 19. Anterior and middle tibiae of the females are not mucronate on the inner margin at apices as they are in the males.

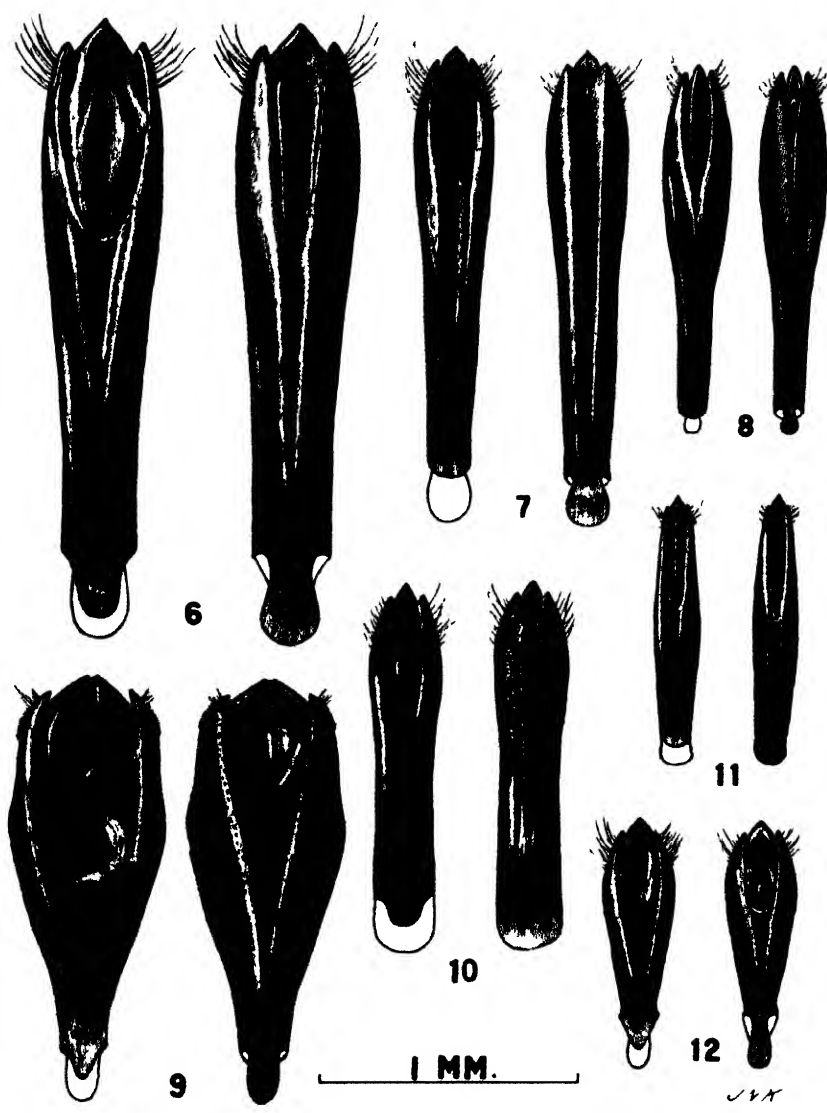
#### ***Agrilus baboquivari* Fisher**

Adults were collected from desert hackberry (*Celtis pallida* Torr.) in which the species breeds in Santa Rita Mts., Tucson Mts., and at Florence, Ariz., in Aug.

### EXPLANATION OF PLATE II

Male genitalia of *Agrilus*; the figure on the left represents the dorsal surface, and the one on the right represents the ventral area.

FIGURE 6, *cavifrons* Water.; 7, *fisherianus* Knull; 8, *wenzeli* Knull; 9, *santaritae* Knull; 10, *amelanchieri* n. sp.; 11, *parapubescens* Knull; 12, *exhuachucae* Knull.



**Agrilus ventralis** Horn

Figure 15

Three specimens of this rare species are before me from Carlsbad Cavern, N. Mex., May 5, 1934, Phoenix, Ariz., April 12, 1931, both E. D. Ball collector, and Baldwin Lake, Cal., June 27, 1941, collected by the writer and Mrs. Knull.

In the female from New Mexico, the second ventral abdominal segment is only slightly produced into an arcuate lobe in middle. This is quite different from the well developed lobe on the second and third segments of the male.

**Agrilus obolinus** Lec.

Specimens were collected from the foliage of hackberry (*Cellis*) at Brownsville, June 8, and Davis Mts., Tex., June and July.

**Agrilus obsoletoguttatus** Gory

Specimens were reared from cut branches of buckeye (*Aesculus glabra* Wild.) collected at Columbus, Ohio.

**Agrilus lautuellus** Fisher

Collected from black persimmon (*Diospyros texana* Scheele) in which the species breeds, in Uvalde Co. and Val Verde Co., Tex., May and June.

**Agrilus ornatulus** Horn

Collected from the foliage of soapberry (*Sapindus drummondi* Hook & Arn.) in the Davis Mts., Tex., in June.

**Agrilus coeruleus** (Rossi)

This species is well established at Columbus, Ohio. Adults were collected in May and June around ornamental plantings of honeysuckle (*Lonicera* sp.) in which the insect breeds.

**Agrilus amelanchieri** n. sp.

Figure 10

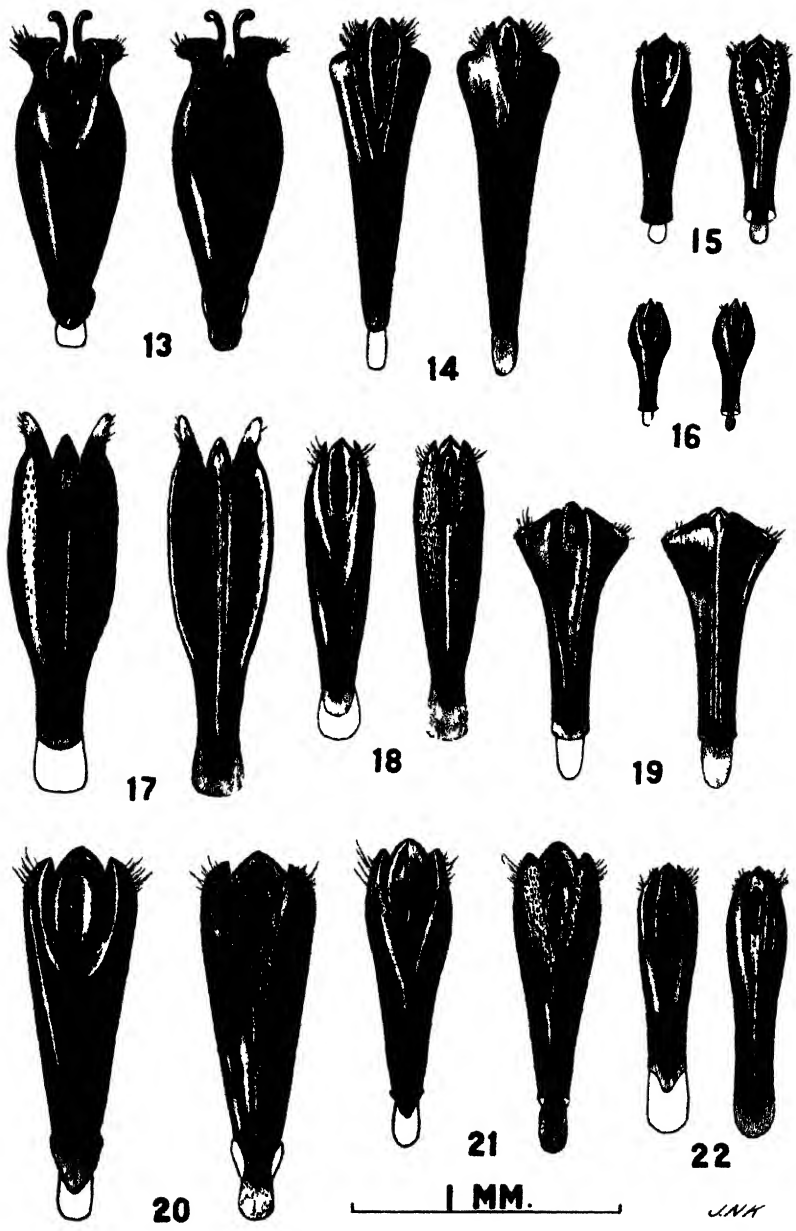
*Male*.—Form of *A. arcuatus* (Say); head with front green, vertex and pronotum brilliant cupreous; elytra piceous; ventral surface cupreous.

Head convex, slightly depressed on top; surface granulate on front becoming finely rugose on vertex, pubescence short; antennae reaching middle of pronotum when laid along side, serrate from the fourth segment.

## EXPLANATION OF PLATE III

Male genitalia of *Agrilus*; the figure on the left represents the dorsal surface, and the one on the right represents the ventral area.

FIGURE 13, *mimosae* Fisher; 14, *parkeri* Knull; 15, *ventralis* Horn; 16, *cercidii* Knull; 17, *osburni* Knull; 18, *viridescens* Knull; 19, *neabditus* Knull; 20, *duncani* Knull; 21, *shoemakeri* Knull; 22, *neoprosopidus* Knull.



Pronotum wider than long, wider at base than at apex, widest in middle; sides broadly rounded in front, sinuate near base; when viewed from the side, marginal and submarginal carinae joined at base; anterior margin slightly sinuate, median lobe broad; basal margin emarginate at middle of each elytron, median lobe truncate in front of scutellum; disk convex, with two median depressions and one deep oblique lateral depression on each side, prehumeral carinae one-third length of pronotum, sharply defined; surface transversely finely rugose, pubescence inconspicuous. Scutellum transversely carinate.

Elytra at base wider than base of pronotum, sides subparallel at base, constricted in front of middle, expanded back of middle, broadly rounded posteriorly to rounded apices, margins serrulate back of middle; disk convex, a strong basal depression each side; surface imbricate, pubescence inconspicuous.

Abdomen beneath finely granulose, pubescence short; first segment somewhat flattened at middle, second segment convex, suture between segments barely indicated at sides; pygidium without projecting carina. Prosternum densely pubescent, hairs extending to first abdominal; prosternal lobe broad, emarginate in front; prosternal process with sides parallel to behind coxal cavities, then obliquely narrowed to acute apex. Tibiae on all pairs of legs mucronate on inner margin at apices. Posterior tarsi shorter than tibiae, first segment nearly as long as three following segments combined. Tarsal claws similar on all feet, cleft near middle, inner tooth stouter and somewhat turned inward, the points not touching.

Length 5.8 mm.; width 1.6 mm.

*Female*.—Differs from the male by lacking mucronate tibiae and line of median ventral pubescence.

Holotype male and allotype female collected in copulation at Mont Alto, Pa., June 21, 1931, by the writer. Paratypes reared June 6-11, 1926, from shad bush, (*Amelanchier canadensis* (L.) Med.) collected in Clark's Valley, Dauphin Co., Pa. Type material in collection of writer.

This is the species recorded by me<sup>2</sup> as *A. arcuatus* (Say), which it superficially resembles. The mucronate posterior tibiae will separate it. It should stand next to *A. crataegi* Frost; it can be separated by the color of head and pronotum as well as shape of pronotum, presence of strong prehumeral carinae, and anterior tarsal claws turned inward.

### ***Agrilus mimosae* Fisher**

Figure 13

Adults were collected in Arizona: Globe, June 10-20, F. H. Parker; Patagonia, June 24, Santa Catalina Mts., June 7, A. A. Nichol; Tucson, May 23, E. D. Ball; Huachuca Mts., July 28, J. S. Hine; Quinlin Mts., July 25, E. D. Ball; Chiricahua Mts., June 20, A. A. Nichol. Texas: Davis Mts., May 25-July 25, D. J. & J. N. Knull.

Mr. Fisher kindly compared a specimen with the unique female type. The male differs from the female by having a median ventral line of pubescence extending from prosternum to second abdominal segment.

<sup>2</sup>J. N. Knull, Ent. News, V. 41, p. 84, 1930.

First and part of second abdominal segments slightly channeled at middle. Front of head green. Tibiae of first two pairs of legs mucronate on inside at apices.

### ***Agrilus neoprosopidus* Knull**

Figure 22

In addition to the holotype, two males and a female of this species have been taken at Brownsville, Tex. In the female the front of head is bronze and the tibiae of the first two pairs of legs are not mucronate on inside at apices.

### ***Agrilus pseudofallax* Frost**

Adults were collected at Columbus, Ohio, in June and July on foliage of honey locust (*Gleditsia triacanthos* Linn.) in the branches of which the species breeds.

### ***Agrilus barberi* Fisher**

Adults were taken by the writer and Mrs. Knull on locust (*Robinia neo-mexicana* Gray) in which the species breeds, in Arizona at Williams, Aug. 9; Prescott, July 14; Oak Creek Canyon, July 13-Aug. 15 and Hualpai Mts., Aug. 6.

THE PERMEABILITY OF NATURAL MEMBRANES, by HUGH DAVSON and JAMES FREDERICK DANIELLI, with a foreword by E. NEWTON HARVEY. Pages x+361, 73 figures, 5¼ x 8½ inches. Published by THE MACMILLAN COMPANY, New York, and THE UNIVERSITY PRESS, Cambridge, England. 1943. Price, \$4.75.

This book presents a general survey of the field of permeability, and contains material essential for students of medicine, physiology, biochemistry, botany, and zoology. Entomologists interested in insect physiology or toxicology will find this book particularly helpful in explaining how insecticides and other materials enter the tissues of an insect. The book contains a great many literature references, which enable the reader to explore the subject further with a minimum of trouble.

The scope of the book is indicated by the chapter headings: 1, Significance of Permeability Studies; 2, Methods of Studying Membrane Permeability; 3, Equilibrium Conditions of Cells; 4, Some Equations Used in Permeability Studies; 5, The Nature of the Process of Diffusion; 6, The Structure of the Plasma Membrane; 7, The Interpretation of Permeability Measurements; 8, Permeability to Non-Electrolytes; 9, Permeability to Gases; 10, Permeability to Water; 11, Permeability to Proteins and to Large Lipoid Molecules; 12, Permeability of Erythrocytes to Ions; 13, Permeability to Ions of Cells Other than the Erythrocyte; 14, Permeability to Weak Electrolytes and Dyes; 15, Impedance and Potential Measurements and Permeability; 16, The Effect of Narcotic Substances on Permeability; 17, The Effect of Temperature on Permeability; 18, Haemolysis; 19, Membrane Permeability in Relation to Secretion; 20, The Kidney; 21, Theories of Cell Permeability; Appendix A, The Theory of Penetration of a Thin Membrane.

This is the first general book on the important subject of permeability that has appeared in the past ten years. Its emphasis is mainly quantitative, as the present-day experimental work in permeability is largely in this direction. This emphasis has been made possible by the recent advances in the field of surface chemistry and the structure of liquids and solids. The contributions of many workers have been drawn upon in achieving a description of how various materials penetrate a membrane. This book marks a big step in our progress in understanding the inner workings of the living organism.--D. J. B.



**CULEX (MELANOCONION) ATRATUS THEOBALD IN  
FLORIDA; A NEW CONTINENTAL NORTH AMERICAN  
RECORD, WITH NOTES ON THE OTHER  
MELANOCONIONS OF THE SOUTH-  
EASTERN UNITED STATES**

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A single male of *Culex (Melanoconion) atratus* Theobald, the first known North American record of the species, was taken December 9, 1942, in a light trap on Boca Chica Key, Florida. Other mosquitoes represented in the same collection are as follows: 59 ♂ and 2675 ♀ *Aedes taeniorhynchus* (Wied.), 3 ♀ *Aedes sollicitans* (Walk.), 4 ♀ *Anopheles atropos*, D. & K., 1 ♂ and 4 ♀ *Deinocerites cancer* Theob., 1 ♀ *Culex bahamensis* D. & K., and 2 ♀ *Culex (Melanoconion)* sp. which may be *Culex atratus*.

The male *C. atratus*, although damaged, was positively identified by the hypopygium which agrees closely with specimens borrowed from the United States National Museum. Dyar (1928) records the species from the Virgin Islands (St. Thomas), Jamaica, Cuba, and Haiti.

The discovery of *atratus* on the Lower Florida Keys is not surprising when one considers the many other Antillean animals and plants which have succeeded in reaching those islands and establishing themselves there. Boca Chica Key is near Key West where shipping from the West Indies is continually arriving, and the present species could have been accidentally introduced by this means or arrived by more natural means across the channel from Cuba. Dyar states that the species breeds in "ground pools," and there are numerous freshwater ponds and pools on many of the Lower Keys which are probably suitable for its development.

Several other West Indian species have been found on the Lower Keys, notably *Anopheles albimanus* Wied., an important vector of malaria, which was introduced into Key West in 1904, but failed to become established. It very probably arrived as a waif on some ship. *Culex bahamensis*, on the other hand, has established itself on several of the Keys and probably represents a natural migrant. Further collecting in some of the more inaccessible places will probably add other species to our list.

The genitalia of *Culex atratus* are quite characteristic and differ greatly from those of the other Melanoconions found in the Southeast. Dyar's figure of the terminalia is drawn on too small a scale to show all the parts distinctly. The present description of the genitalia supplements that given by Dyar.

The larvae have not as yet been collected on the Keys and none were available. Lt. Col. Willard V. King examined one larval slide

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<sup>1</sup>Second Lieutenants, Sanitary Corps, Army of the United States.

labeled *Culex atratus* at the United States National Museum, but stated that it was too badly damaged to describe. Since Dyar's works are not too widely available, his characterization of the larva is repeated here.

*Larva.* --Head transverse, bulging on the sides; antennae large, a tuft of hair at the outer third, the part beyond slender, basal part spinulated. Head hairs, upper a small tuft of five, lower a long single hair. Lateral comb of the eighth segment of many small spines in a patch four rows deep. Air-tube long and slender, straight, a little flared at the base, about nine times as long as wide, the pecten reaching the basal third, followed by five short tufts, decreasing in number of

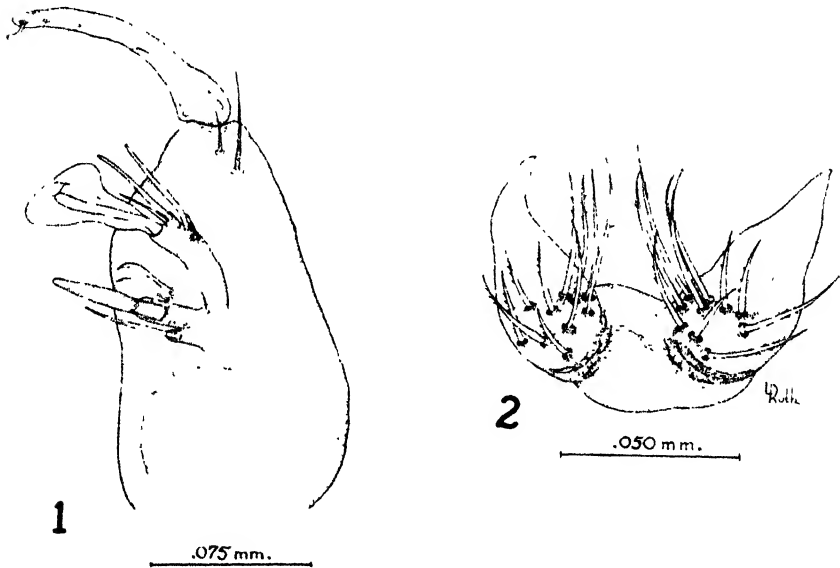


FIGURE 1. Sidepiece of the terminalia of *Culex atratus*. Inner view, outer setae and pilosity not indicated. 2. Lobes of the ninth tergite of *Culex atratus*. Figs. 1 and 2 drawn with the aid of an ocular grid

hairs outwardly, but all of about equal length; a single hair and a small two-haired tuft on the side. Skin pilose. Anal segment longer than wide, ringed by the plate, the ventral brush posterior; dorsal tuft a long hair and a long and two short hairs on each side. Anal gills very small, not as long as the width of the segment.

*Hypopygium* (figs. 1 and 2).--Side piece elliptical, convex outwardly. Basal and apical divisions of the subapical lobe well separated; basal division of the lobe columnar, with a slender lower seta from its base; upper seta acuminate, but stout and rather rod-like; apical division curved from the base of the basal with a broad ribbed leaf from its tip, behind which arises a stout recurved seta. (This seta is constricted just before the recurved tip in our Floridian specimen,

but the Antillean ones examined lacked this constriction.) Two conspicuous slender setae arise on the outer side of the apical division each with a smaller, inconspicuous seta from near its base. The clasper slender, uniform, the base a little enlarged with a somewhat clavate subterminal seta. In our specimen, three apically broadened setae arise from the side piece between the apical and basal divisions of the subapical lobe, and are partly hidden by the basal portion. (In the Antillean specimens, however, the number of these setae varied from 4 to 6.) Tenth sternites narrow, provided with teeth giving a comb-like appearance. Ninth tergites pear-shaped, tapering to a point, and with a number of barbed setae arising from conspicuous tubercles on the basal half. Mesosomal plate a stout, curved, simple blade.

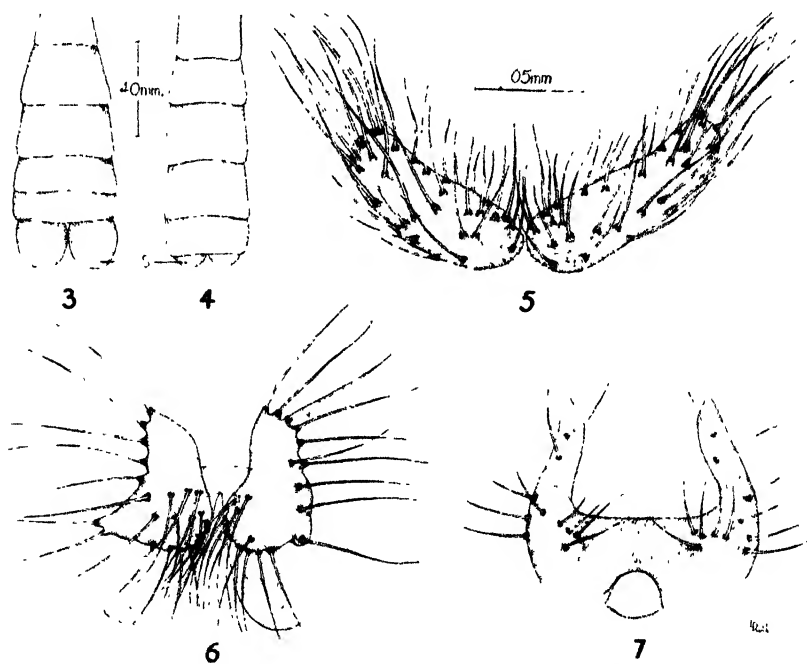


FIGURE 3. Dorsal view of the abdominal segments of *Culex peccator*. S=side-pieces of the terminalia. 4. Dorsal view of the abdominal segments of *Culex erraticus* (somewhat similar in *Culex pilosus*). 5. Lobes of the ninth tergite of *Culex erraticus*. 6. Lobes of the ninth tergite of *Culex pilosus*. 7. Ninth tergite of *Culex pilosus*.

All figures outlined with the aid of an ocular grid. Figs. 5, 6, 7, drawn to the same scale.

*Culex atratus* raises to four the number of Melanoconions found in Florida. The others are *Culex erraticus* (D. & K.) and *C. peccator* D. & K., both also found in the other southeastern states (Georgia, Alabama, Mississippi, Louisiana, Arkansas, Tennessee, North Carolina,

and South Carolina), and *Culex pilosus* (D. & K.) which has been recorded from all these states except Arkansas and Tennessee.

As pointed out by King, Bradley, and McNeel (1942) the "adults of the Melanoconion species cannot be identified with certainty except by characters of the male terminalia . . ." (p. 70). However, it might be well to add that the male of *C. peccator* may be distinguished macroscopically from the other species by the fact that the abdominal segments gradually increase in width and the sidepieces of the terminalia are large and bulbous and well exposed (fig. 3). The other Melanoconions have the margins of the abdominal segments nearly parallel and the comparatively small sidepieces are more or less hidden by the last abdominal segment (fig. 4).

The most distinctive character of the terminalia is the shape of the lobes of the ninth tergites, although other differences are present. Figures of the entire genitalia are already to be found in the literature (Dyar, 1928; Matheson, 1929, *et al.*), but the ninth tergites are seldom clearly indicated. Therefore it appears worthwhile to include drawings of these structures in the present paper. King and Bradley (1937) have listed and discussed the synonymy of the subgenus *Melanoconion* in the United States, and their paper includes three other species, *Culex inhibitor* D. & K., *Culex abominator* D. & K., and *Culex anips* Dyar.

The key to the male terminalia of the dark-legged species of *Culex*, given by King, Bradley, and McNeel (1942), is modified here to include the new form *Culex atratus*. The descriptions of the ninth tergites have been amplified, while that portion of the key dealing with the subgenus *Culex* is omitted:

1. Tenth sternite with an apical tuft of short bristles or spines . . . Subgenus **Culex**
2. Tenth sternite comb-shaped apically, with a row of fairly stout teeth . . . 2
2. Subapical lobe of sidepiece with a distinct division; mesosomal plate with a long, curved basal arm (basal hook), directed ventrally (except in *Culex atratus*) . . . Subgenus **Melanoconion**
- Subapical lobe not distinctly divided; mesosomal plate without a basal hook; outer end of mesosomal plate studded with small tubercles. . . Subgenus **Neoculex**, **Culex apicalis**
3. Apical division of the subapical lobe of the sidepiece with a distinct broad flat leaf . . . 4
- Apical division of the subapical lobe lacking an expanded leaf but with several rod-like filaments; lobes of the ninth tergite finger-like projections from the corners of a broad, spicular plate, which has a central oval or irregularly ovate lacuna; one or two smooth setae on each lobe and several grouped on the posterior corners of the plate (fig. 7); apical swelling of the clasper cap-shaped, tapering abruptly . . . **Culex pilosus**
4. Clasper gradually tapered with very little apical swelling . . . 5
- Clasper greatly enlarged apically with the outer and front margin of the expanded quadrangular portion hirsute, the stem stout and constricted near the middle; lobes of ninth tergite roughly triangular, approximate, the outer and lower margins and basal portion of each with long, smooth setae arising from conspicuous tubercles (fig. 6) . . . **Culex peccator**
5. Lobes of the ninth tergite ovate, prominent, with numerous smooth setae arising from prominent tubercles; numerous small spicules on the lower base of each lobe (fig. 5) . . . **Culex erraticus**
- Lobes of ninth tergite somewhat pear-shaped with a number of barbed setae arising from the basal half (fig. 2); apical and basal portions of the subapical lobe well separated, the basal portion with an upper stout, rod-like seta and a slender lower one (fig. 1); mesosomal plate a stout, curved, simple blade . . . **Culex atratus**

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AN OUTLINE OF GENERAL PHYSIOLOGY, by L. V. HEILBRUNN. Pages xii+748, 135 figures, 6 x 9 1/4 inches. Published by W. B. SAUNDERS COMPANY, Philadelphia. Second edition, 1943. Price, \$6.00.

Most entomologists, particularly those interested in ecology or in the action of insecticides, are well aware of the importance of an understanding of physiology and physiological techniques in the solution of their problems. Most courses and texts on physiology are concerned mainly with mammalian or human physiology, and treat the invertebrates only incidentally or not at all. The present book is one of the few good texts on general physiology which deals with invertebrates as well as vertebrates, and hence should be of particular value to entomologists.

As the title indicates, this book is essentially an outline. One of the objectives of the author has been to present a source book for the various branches of the subject. The discussions are usually brief, and the reader's attention throughout the book is directed to sources of additional information by means of footnote literature citations. The total number of these citations is about four thousand.

This second edition has the same general arrangement and chapter headings as the first edition. Space here will not permit a complete listing of the 42 chapter headings, but a brief outline will indicate the broad scope of the text. Following a brief introductory chapter outlining the nature of the subject, the early chapters deal with the statics of living systems: one chapter on cell morphology, five chapters on the chemical make-up of protoplasm, and six chapters on the physical properties of living systems (including the colloidal chemistry of protoplasm, surface phenomena, osmosis, and permeability). Then follow nine chapters on the various aspects of metabolism: nutrition, digestion, absorption, growth, respiration, secretion, and excretion. There are eight chapters on the physical aspects of vital activity: types of movement, muscle action, and the production of mechanical energy, heat, electricity, and light. The next ten chapters deal with the living organism in relation to its environment: three chapters on the effect of temperature, pressure, light, and chemical factors; the remaining chapters in this group deal with the various aspects of irritability and response to stimuli, including the physiology of nerve action, receptors, and tropisms. The two final chapters deal with cell division and senescence. At the end of the book are very complete author and subject indices.

The present volume is considerably larger than the first edition (748 as compared with 603 pages), and brings the account up to date. There is a great deal more material on the lower organisms (including insects), and information about such new topics as the vitamin needs of lower organisms, the relation of vitamins to oxidative processes, the localization of enzymes within various parts of the cell, and new techniques such as the use of tracer elements and the electron microscope. There are about twice as many literature citations as were in the first edition.

Dr. Heilbrunn is a professor of zoology at the University of Pennsylvania. He has done considerable research on various aspects of the physical chemistry of protoplasm and cell division, and is a leading authority in this field. He has also had experience in editorial work, which is manifest in the present carefully written and edited text. He has the viewpoints of both the research worker and the teacher, and these are reflected in the refreshingly different and often challenging style of his writing. It is well worth while for entomologists to become acquainted with the writings of such top-flight physiologists as Dr. Heilbrunn.—D. J. B.

# THE NEOTROPICAL COCCID-TENDING ANTS OF THE GENUS ACROPYGA ROGER

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Recent studies by Bünzli (1935) have demonstrated the importance of ants of the genus *Acropyga* (subgenus *Rhizomyrma*) to the cultivation of coffee in Surinam. The ants (*Rhizomyrma paramaribensis* Borgmeier and *R. rutgersi* Bünzli) tend coccids<sup>1</sup> on the roots of the Liberian coffee trees and these coccids transmit an infectious phloëmnecrosis. This phloëmnecrosis in epidemic years caused a loss of 20-40 per cent of the coffee production in many fields in Surinam (Stahel, in Bünzli, p. 559). Earlier studies by Goldi (1892), Pickel (1927) and Costa Lima (1928) showed that coccids (*Rhizoecus coffeae* Laing) tended by other species of this subgenus caused severe injury to coffee trees in northeast Brazil. According to Donisthorpe (1936) a species of *Rhizomyrma* has recently been taken associated with a coccid at the roots of coffee in Colombia.

Incidental to studies on leaf-cutting or fungus-growing ants<sup>2</sup> I was able to collect and make observations on a number of known and new species of this hypogaecic ant genus with their coccids.<sup>3</sup> They confirm the much more extensive Brazilian and Surinam biological studies and also indicate that this ant-coccid association may be of importance to the cultivation of cacao as well as possibly other economically important plants such as banana. The collections and observations were made in Trinidad, Venezuela, British Guiana, Colombia, Panama and Haiti. In Trinidad the ants with their coccids were usually found about the roots of cacao, one of the most important crops in this British colony. On three occasions the coccids clearly were pastured on the roots of cacao while in six other instances they were pastured on roots under cacao, coffee, and banana which may have belonged to any one or to all of these plants. One collection of *Rhizomyrma* in British Guiana was of workers found tending coccids on the grass, *Axonopus compressus*. This is a widely used tropical pasture grass. In Venezuela a large colony of *Rhizomyrma* was found tending coccids on roots at the base of a banana clump. These ants with their coccids were discovered on

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<sup>1</sup>*Rhizomyrma paramaribensis* tends the coccids *Rhizoecus coffeae* Laing, *R. caludii* Green, *R. moruliferus* Green, *Geococcus coffeae* Green, and *Pseudorhizoecus proximus* Green. *Rhizomyrma rutgersi* tends the coccids *Pseudorhizoecus proximus* Green, *P. migrans* Green, and *Pseudococcus radialis* Green.

<sup>2</sup>Most of the earlier studies were made while holding a National Research Fellowship in Biology at the Imperial College of Tropical Agriculture, Trinidad, B. W. I.

<sup>3</sup>Representative coccids from these collections are in the hands of Dr. Harold Morrison of the U. S. Department of Agriculture for identification. Specialists in insect groups are usually overburdened with material for identification. The common Trinidad type, a sketch of which appears in this paper, has been referred to as "*Eumyrnococcus* or to some other very closely allied genus," (Wheeler, 1935, p. 325).

roots of coffee in Haiti. Since coccids carried by these ants have been proved to be the vector of an important disease of coffee in Surinam, the findings here reported would suggest that the *Rhizomyrma*-coccid relationship be thoroughly investigated as a possible factor in disease of cacao, coffee and banana in other neotropical countries. Whether a disease is actually transmitted by the coccids or not, the loss of sap alone from the roots is of importance and must weaken the vitality of the trees.

The association between the ants and the coccids is not haphazard but a definite symbiotic arrangement. Not only are the ants and coccids usually, if not always, found together in the same tunnels, but the ants care for the coccids as they care for their own brood and in addition actually disseminate the coccids from place to place. It is quite possible that *Rhizomyrma* ants are obligate coccidophiles, in the New World at least.

These ants have become adapted to their mode of life in several ways. Living underground as they do, there has been a considerable loss of pigment, which loss has been greatest in the worker caste. This caste is pale yellow or brownish-yellow while the female is somewhat darker but never darker than brownish-yellow. Even the comparatively stable male caste is in *Rhizomyrma* only medium brown while in many genera of ants this caste is dark brown or black. Accompanying the loss of pigment in the worker has been a reduction in the eyes so that they have become mere vestiges, pin-points 0.02-0.06 mm. in diameter. The eyes in the female and male are of normal size and they swarm in the air in the usual fashion. The general habitus of the worker is a small to minute size with moderately short legs and no spines or other attenuations of the body which might impede their passage through the soil. All castes have long hairs on the clypeus, especially on the anterior margin, with one hair much the longest and extending well across the space between the closed mandibles and the clypeus. These hairs are doubtless useful in caring for, and carrying, not only their larvae but their coccids.

There are four subgenera of *Acropyga* (*Acropyga*, *s. str.*, *Atopodon*, *Malacomyrma* and *Rhizomyrma*) but only *Rhizomyrma* is recorded from the New World. The subgenera are separated chiefly on the characteristics of the mandibles, the number of antennal segments, and the geographical distribution, but all are closely related and the subgenus *Rhizomyrma* alone contains species running the gamut of mandibular and antennal characters. *Rhizomyrma* was established by Forel in 1893 (Trans. Ent. Soc. London, Part IV, pp. 347-348), as a subgenus of *Acropyga* with the worker characteristics of 7-11 segmented antennae, 2-segmented maxillary and 3-segmented labial palpi, long, narrow mandibles with 3-4 teeth on an extremely oblique border, extremely small eyes, no ocelli, frontal area triangular and distinct, antennae clavate, but otherwise like the other *Plagiolepidini*. The single female which Forel had seen lacked wings and was described merely as like the worker. The male caste was undescribed.

This paper brings together for the first time descriptions of all of the known species of *Rhizomyrma* in the New World. Some of the species are known only from specimens in European or South American

collections which are unavailable for study. Some are unusually hard to evaluate because of the variability in characters or subtle differences in proportions which are difficult to show by description or drawing. The original drawings of *R. rugersi*, for example, show workers with such differences as to indicate that they belong to two species and I have had much trouble in determining whether certain Trinidad, Venezuela and British Guiana ants actually belong to this species.

The species are arranged in chronological order of their description with the new species at the last. The biology of the different species is treated at the end of the taxonomic description of each.

#### KEY TO THE NEOTROPICAL SPECIES OF ACROPYGA (RHIZOMYRMA) BASED ON THE WORKER<sup>4</sup>

1. Antennae 7-8 segmented . . . . . 2  
    Antennae with 8 or more segments . . . . . 3
- 2 (1). Mandibles 3-4 toothed; length 1.8 mm.; head approximately as broad  
    as long; antennal scape extending about three-fifths the distance to the  
    occiput (Surinam, B. Guiana) . . . . . **paramaribensis**  
    Mandibles 4-toothed; length 1.5-1.9 mm.; head 1.1 times longer than broad;  
    dorsal surface of thorax plane (Trinidad) . . . . . **urichi**
- 3 (1). Antennae 8-segmented; mandible 4-toothed . . . . . 4  
    Antennae 8-11 segmented . . . . . 7
- 4 (3). Head 1.3 times longer than broad (Panama) . . . . . **panamensis**  
    Head 1.1 times longer than broad . . . . . 5
- 5 (4). Length 1.2-1.3 mm.; antennal scape extending about three-fourths the  
    distance to the occiput (Trinidad, Panama) . . . . . **kathrynae**  
    Size larger, scape longer . . . . . 6
- 6 (5). Length 1.3-1.8 mm.; antennal scape failing to reach occiput by about  
    twice its distal diameter (Trinidad) . . . . . **berwicki**  
    Length 1.7-1.9 mm.; antennal scape nearly attaining occiput (Colombia)  
    . . . . . **fuhrmanni**
- 7 (3). Antennae 8-9 segmented; mandible 3-toothed . . . . . 8  
    Antennae 9-11 segmented . . . . . 9
- 8 (7). Length 1.4-1.6 mm.; funicular segments 5-6 much broader than long  
    (Mexico) . . . . . **exsanguis**  
    Length 2 mm.; funicular segments 5-6 as long as broad (Colombia) . . . . . **robae**
- 9 (7). Antenna 9-segmented; mandibles 3-toothed . . . . . 10  
    Antennae 9-11 segmented; mandibles 3-4 toothed . . . . . 11
- 10 (9). Length 1.5 mm.; head longer than broad (Honduras, Panama) . . . . . **wheeleri**  
    Length 2 mm.; head broader than long (Argentina) . . . . . **bruchii**
- 11 (9). Head as broad or broader than long . . . . . 12  
    Head longer than broad . . . . . 20
- 12 (11). Head as broad as long . . . . . 13  
    Head broader than long . . . . . 14
- 13 (12). Length 1.8-2.1 mm.; antennal scape exceeding occiput (Haiti) **mesonotalis**  
    Length 2.2 mm.; antennal scape failing to reach occiput (Brazil) **pachycera**
- 14 (12). Mandibles 3-toothed . . . . . 15  
    Mandibles 3-4 toothed . . . . . 16
- 15 (14). Head 1.2 times broader than long; penultimate antennal segment barely  
    broader than long (Barbados) . . . . . **marshalli**  
    Head 1.0-1.1 times broader than long; penultimate antennal segment  
    markedly longer than broad (Trinidad) . . . . . **trinitatis**
- 16 (14). Mandibles with 4 very small teeth; length 1.8-2 mm. (Haiti) . . . . . **parvidens**  
    Mandibles with 3-4 well-developed teeth . . . . . 17

<sup>4</sup>Because of the unavailability of some species it has been necessary to use in this key the variable characters of antennal-segment and mandibular-tooth numbers which are known for all. In some instances the key will serve only to limit identification to several species and recourse must then be had to the description and figures of these.



- 17 (16). Head quadrate, occiput not impressed, length 2.7–2.9 mm. (Trinidad)  
 Head or size different . . . . . **quadriceps** 18
- 18 (17). Length 2.4–3.2 mm., mandibles 3–4 toothed: female 3.6–4.8 mm. long,  
 male 2.8–3 mm. long, with 12-segmented antenna (Surinam, B. Guiana,  
 Trinidad) . . . . . **rutgerai**
- Smaller in all castes . . . . . 19
- 19 (18). Antennal scape exceeding occiput; female 3–3.3 mm. long, antennae  
 9-segmented; male 2 mm. long, antenna 11-segmented (Brazil) . . . **decedens**
- Antenna not attaining occiput; female 2.8 mm. long, antennae 11-seg-  
 mented; male 1.3–1.6 mm. long, antennae 9-segmented (Brazil, Surinam)  
 . . . . . **pickeli** 21
- 20 (11). Antennal scape exceeding occiput . . . . . 22
- Antennal scape not attaining occiput . . . . . 22
- 21 (20). Head 1.1 times longer than broad; diastema between the basal and  
 third mandibular tooth marked (Brazil, B. Guiana) . . . . . **göldii**
- Head 1.2 times longer than broad; diastema between the basal and third  
 mandibular tooth less marked (B. Guiana) . . . . . **guianensis**
- 22 (20). Head barely longer than broad; length 1.7 mm. (thorax 0.55 mm.); eyes  
 0.04 mm. in diameter (B. Guiana) . . . . . **oko** 23
- Head longer . . . . . 23
- 23 (22). Length 2.4–2.8 mm. (thorax 0.6 mm.); eyes 0.06 mm. in diameter (B.  
 Guiana) . . . . . **paludis**
- Length 2.1–2.4 mm. (thorax 0.55–0.57 mm.); eyes 0.03 mm. in diameter  
 (B. Guiana) . . . . . **donisthorpei**

### **Acropyga (Rhizomyrma) decedens (Mayr)**

1887. *Brachymyrmex decedens* Mayr, Vehr. zool.-bot. Ges. Wien, 37: 521 (worker,  
 female, male).
1892. *Brachymyrmex decedens* Goldi, Arch. Mus. Nac. Rio de Janeiro, 8: 176  
 (worker).
1905. *Rhizomyrma decedens* Emery, Bull. Soc. Ent. Ital., 37: 184, fig. (worker).
1914. *Rhizomyrma decedens* Wheeler, Bull. Amer. Mus. Nat. Hist., 33: 46 (worker).
1925. *Acropyga (Rhizomyrma) decedens* Emery, Genera Insectorum, Fasc. 183,  
 p. 29 (worker, female, male).
1931. *Acropyga (Rhizomyrma) decedens* Borgmeier, Rev. Ent., 1: 105 (worker).
1931. *Acropyga (Rhizomyrma) decedens* Costa Lima, Bol. Biol., Fasc. 17, pp. 2–7  
 (worker).
1932. *Acropyga (Rhizomyrma) decedens* Costa Lima, Bol. Biol., Fasc. 21, pp. 65–68  
 (worker).
1935. *Acropyga (Rhizomyrma) decedens* Wheeler, Jour. New York Ent. Soc.,  
 43: 322, 327, 328 (worker, female, male).
1936. *Acropyga (Rhizomyrma) decedens* Donisthorpe, Entomologist, 69: 110  
 (worker, female, male).

**Worker.**—Length 2–2.5 mm. Head, excluding mandibles, slightly broader than long, slightly broader in front than behind, broader than thorax, occipital margin nearly straight, faintly concave, anterior clypeal margin convex, eyes small, situated at a level with the posterior margin of the frontal lobes; mandibles 4-toothed, the teeth well developed and situated on a cutting margin nearly at right angles to the inner margin; antennae 9–11 segmented, scapes distinctly exceeding occipital angles, terminal segment distinctly longer than the preceding three taken together but shorter than the preceding four. Pilosity of scanty, long, upright hairs and abundant golden pubescence; yellow, mandibular teeth red-brown. (Mayr, Emery fig.).

**Female.**—Length 3–3.3 mm. Mandibles with 4 large, acute teeth; antennae in 3 females 9-segmented, in 7 females the 2nd funicular segment seems divided into two. (Mayr.)

*Male*.—Length 2 mm. Antennae 11-segmented, scape exceeding occiput, 1st funicular segment twice as long as broad. (Mayr).

*Type locality*.—Est. Rio de Janeiro, Brazil.

The types were taken by Göldi in 1892 at the roots of coffee with coccids. The coccids were referred to at the time as *Dactylopius* but have since been referred to as of the species *Rhizococcus coffeae* Laing.

### ***Acropyga (Rhizomyrma) göldii* Forel**

Figure 14

- 1893. *Acropyga (Rhizomyrma) göldii* Forel, Trans. Ent. Soc. London, pp. 348-349 (worker).
- 1912. *Rhizomyrma goeldii* Forel, Mém. Soc. Ent. Belg., 20: 60 (worker).
- 1914. *Rhizomyrma goeldii* Wheeler, Bull. Amer. Mus. Nat. Hist., 33: 46 (worker).
- 1925. *Acropyga (Rhizomyrma) goeldii* Emery, Genera Insectorum, Fasc. 183, p. 29, Pl. I, fig. 15 (worker, female wing).
- 1931. *Acropyga (Rhizomyrma) göldii* Costa Lima, Bol. Biol., Fasc. 17, pp. 4-7 (worker).
- 1932. *Acropyga (Rhizomyrma) goeldii* Costa Lima, Bol. Biol., Fasc. 21, pp. 65, 67-8 (worker).
- 1933. *Acropyga (Rhizomyrma) goeldii* Borgmeier, Rev. Ent., 3: 263 (female wing).
- 1935. *Acropyga (Rhizomyrma) goeldii* Wheeler, Jour. New York Ent. Soc., 43: 327 (worker).
- 1936. *Acropyga (Rhizomyrma) goeldii* Donisthorpe, Entomologist, 69: 110 (worker).

*Worker*. Length 2-2.3 mm. Head rectangular, broader than long, broader in front than behind; eyes very small, composed of two or three atrophied facets situated at the anterior third of the sides; mandibles 3-4 toothed, with three long, acute teeth and basally a minute denticle; antennae 10-11 segmented, antennal scapes slightly surpassing the occipital border, terminal segment of funiculus swollen, almost as long as the four preceding segments taken together, funicular segments 2-9 one one-fourth times broader than long. Thorax slightly concave longitudinally, mesonotum large and very elevated, meso-epinotal impression very distinct, epinotum rounded, declivous face much longer than the basal. Petiolar node very compressed, oval-rectangular. Legs very short, tarsi a little stout.

Smooth, shining, very finely and regularly punctate. Pilosity of erect, pale yellow, very fine, pointed hairs of irregular length which are abundant over the entire body, and a moderately abundant oppressed yellowish pubescence which is somewhat more abundant on the gaster; tibiae and scapes with very short hairs, oblique on the tibiae, upright on the scapes. Very pale yellow, slightly brighter than in *R. smithi*. (Forel).

*Type locality*.—Parahyba, Prov. Rio de Janeiro, Brazil

Cultivating coccids on the roots of coffee.

The British Guiana workers described below agreed perfectly with specimens from Pará, Brazil, (Beebe) determined as *R. göldii* by Dr. W. M. Wheeler. They differ from Forel's description, however, chiefly in having the head distinctly longer than broad and the eyes larger (0.036 mm.), being composed of about six facets. The occipital margin is feebly impressed; the anterior clypeal margin feebly convex, the mandibles 4-toothed and the antennae are 10-segmented although several have indications of an eleventh segment forming, with the scapes

distinctly exceeding the occipital angles. The anterior face of the petiolar scale is convex, the posterior face is feebly concave and the dorsal crest is strongly convex.

**Biology.**—In virgin rain forest containing many Brazil nut trees (*Bertholletia* sp.) along the New River, in the neighborhood of 3° N. Lat. and 57° W. Long., Couratyne basin, British Guiana, a colony of this species was found July 18, 1936 (No. 576). The ants were tending the common Trinidad type of coccids on rootlets of small plants which were interwoven into the husk of a Brazil nut fruit lying on the ground. Under the husk was yellow sandy clay soil in which the ants had tunnels. The workers maintained the same solicitude for the coccids as did the Trinidad species and carried them off, dorsal side up and anterior end forward, between the ants' legs. Since only coccids were found here and no ant brood the workers evidently had their nest some distance off. Because this was merely a noon stop during strenuous traveling through falls and rapids by boat there was no time for investigating this association.

***Acropyga (Rhizomyrma) göldii* var. *columbica* Forel**

1912. *Acropyga (Rhizomyrma) goeldii* var. *columbica* Forel, Mém. Soc. Ent. Belg., 20: 61 (worker).  
1925. *Acropyga (Rhizomyrma) goeldii* var. *columbica* Emery, Genera Insectorum, Fasc. 183, p. 29.

**Worker.**—Length 2.2 mm. Mandibles 3-toothed; differing from the type of the species by the funicular segments 2-9 being about twice as broad as long and the tarsi somewhat less thickened. (Forel).

**Type Locality.**—Colombia, presumably, although no locality is stated.

***Acropyga (Rhizomyrma) göldii* var. *tridentata* Forel**

1912. *Acropyga (Rhizomyrma) goeldii* var. *tridentata* Forel, Mém. Soc. Ent. Belg., 20: 61 (male, female).  
1925. *Acropyga (Rhizomyrma) goeldii* var. *tridentata* Emery, Genera Insectorum, Fasc. 183, p. 29.

**Female.**—Length 3.3-3.5 mm. Head transversely rectangular, 0.7 x 0.57 mm., the occipital margin straight; eyes very small, situated at the anterior third of the head; mandibles with three long, acute teeth, without trace of a denticle; antennal scape surpassing occipital margin by twice its diameter, funicular segments slightly broader than long. Thorax and head equally broad, epinotum moderately convex, junction of basal and declivous surfaces indistinguishable. Wings blackish. Less shining and above all much more densely pubescent and punctate than in the typical *göldii*. Yellow with a touch of brown. (Forel).

**Male.**—Length 2.5-2.6 mm. Head squarish, slightly broader than long; mandibles 3-toothed; antennae 12-segmented, scape surpassing occipital margin by a fourth its length, middle segments of funiculus slightly broader than long. Thorax broader than head, exterior genital valves very large, very long, terminating in a long, flattened point, recurved above; there is a strongly and vertically recurved prolongation of the middle valves surpassing the border of the exterior

valves. More shining than in the female, otherwise similar. Dark brown, thorax and appendages clear brown. Wings tinted with blackish brown. (Forel).

*Type Locality*.—Panama. Taken by Christopherson from a nuptial flight.

### ***Acropyga (Rhizomyrma) smithi* Forel**

1893. *Acropyga (Rhizomyrma) smithi* Forel, Trans. Ent. Soc. London, p. 349 (female).  
 1914. *Rhizomyrma smithi* Wheeler, Bull. Amer. Mus. Nat. Hist., 33: 46 (female).  
 1925. *Acropyga (Rhizomyrma) smithi* Emery, Genera Insectorum, Fasc. 183, p. 30 (female).  
 1935. *Acropyga (Rhizomyrma) smithi* Wheeler, Jour. New York Ent. Soc., 43: 328 (female).  
 1936. *Acropyga (Rhizomyrma) smithi* Donisthorpe, Entomologist, 69: 110 (female).

*Female*. -- Length 2.0–2.2 mm. Head an elongate rectangle, much longer than broad, sides and posterior border straight, anterior margin of clypeus emarginate on each side, truncate and slightly concave in the middle, frontal carinae composed of an anterior portion in the form of a small, horizontal lobe and a posterior portion strongly divergent; frontal groove feeble but visible; eyes flat, very large, close to the anterior angles of the head; mandibles 3–4 toothed, feebly curved; antennae 7-segmented, scape extending to a level with the anterior ocellus, terminal funicular segment longer than the preceding 4 taken together, first funicular segment as long as the two following taken together, segments 4–5 broader than long. Pronotum not overhung by mesonotum, scutellum flattened, epinotum rounded. Petiolar node vertical, small, rectangular, the dorsal margin right-angled. Legs short

Very shining, smooth, finely and abundantly punctate. Hairs short, fine, pointed, scattered over body, lacking on scapes and tibiae; pubescence sub-appressed, pale yellow, short and widespread on body, legs and antennae. Pale yellow, mandibular teeth reddish, infuscated about ocelli and anteriorly on head. Wings lacking. (Forel).

*Type Locality*. -- St. Vincent, British West Indies.

The single female was collected by H. H. Smith on Morne à Garou at an elevation of 1500 feet under the bark of a rotten log.

### ***Acropyga (Rhizomyrma) pachycera* Emery**

1905. *Rhizomyrma pachycera* Emery, Bull. Soc. Ent. Ital., 37: 182 4, Fig. 44 (worker, female).  
 1914. *Rhizomyrma pachycera* Wheeler, Bull. Amer. Mus. Nat. Hist., 33: 46–47 (worker).  
 1925. *Acropyga (Rhizomyrma) pachycera* Emery, Genera Insectorum, Fasc. 183, p. 30 (worker, female).  
 1931. *Rhizomyrma pachycera* Borgmeier, Rev. Ent., 1:106 (worker).  
 1935. *Acropyga (Rhizomyrma) pachycera* Wheeler, Jour. New York Ent. Soc., 43: 327, 328 (worker, female).  
 1936. *Acropyga (Rhizomyrma) pachycera* Donisthorpe, Entomologist, 69: 110 (worker, female).

*Worker*.—Length 2.2 mm. Head, excluding mandibles, as broad as long (in figure), occipital margin straight, sides sub-parallel, anterior

clypeal margin convex; mandibles 4-toothed, masticatory margin oblique; antennae 9-segmented, scapes not reaching occipital margin. Pale yellow. (Emery).

*Female*.—Length 3.7 mm. Antennal scapes attain occipital angles, funicle somewhat more slender than in worker. Thorax as broad as head.

*Type Locality*.—Tacurù Pucu (Alto Paraná), Brazil.

### **Acropyga (Rhizomyrma) exsanguis** Wheeler

1909. *Rhizomyrma exsanguis* Wheeler, Boll. Lab. Zool. Gen. Agr. Portici, 3: 238 (worker).  
 1914. *Rhizomyrma exsanguis* Wheeler, Bull. Amer. Mus. Nat. Hist., 33: 46 (worker).  
 1922. *Acropyga (Rhizomyrma) exsanguis* Mann, Proc. U. S. Nat. Mus., 61: 53 (worker).  
 1925. *Acropyga (Rhizomyrma) exsanguis* Emery, Genera Insectorum, Fasc. 183, p. 29 (worker).  
 1935. *Acropyga (Rhizomyrma) exsanguis* Wheeler, Jour. New York Ent. Soc., 43: 327 (worker).  
 1936. *Acropyga (Rhizomyrma) exsanguis* Donisthorpe, Entomologist, 69: 110 (worker).

*Worker*.—Length 1.4-1.6 mm. Mandibles long, slender, uniformly curved, with parallel borders and 3 acute, oblique teeth. Antennae 8-9 segmented, scapes reaching almost to the occipital corners of the head, all funicular segments, except first and second much broader than long. Eyes extremely minute. Thorax as in *göldii*. Subopaque or finely shining. Hairs very sparse, pubescence not very abundant. Pale yellow. (Wheeler).

Mexico: Jalapa (F. Silvestri). This locality, near Vera Cruz in Latitude 19° 30' N., is the northernmost record for this genus in the New World.

### **Acropyga (Rhizomyrma) fuhrmanni** Forel

Figures 6, 11

1913. *Acropyga fuhrmanni* Forel, Mém. Soc. Sc. Neuchâtel, 5:12 (worker, female).  
 1925. *Acropyga (Rhizomyrma) fuhrmanni* Emery, Genera Insectorum, Fasc. 183, p. 29 (worker, female).  
 1935. *Acropyga (Rhizomyrma) fuhrmanni* Wheeler, Jour. New York Ent. Soc., 43: 327, 328 (worker, female).  
 1936. *Acropyga (Rhizomyrma) fuhrmanni* Donisthorpe, Entomologist, 69: 110 (worker, female).

*Worker*.—Length 1.7-1.9 mm. Head, excluding mandibles, rectangular, a little longer than broad, broadest in front, occipital margin slightly impressed medially; eyes more distinct than in *exsanguis*; mandibles 4-toothed, with a very distinct terminal border; antennae 8-segmented, scape not quite attaining occipital margin. Promesonotum as in *göldii*; petiolar node vertical, smaller than in *göldii*. Shining, finely punctate, pilosity abundant but passing gradually into an oblique pubescence. Pale yellow, mandibles brown. (Forel).

*Female*.—Length 2.5-2.7 mm. Antennae 8-segmented, scape reaching occiput and 2nd funicular segment as long as broad. Slightly dirty yellow, on the vertex, thorax and gaster a somewhat yellowish-

brown blotch. Wings brown, radial cell constant, one cubital cell, no discoidal cell. (Forel).

*Type Locality*.—Puerto de los Pobres, Cauca border, Dép. Antioquia, at an elevation of about 720 m.

Ants which I took in the same region (Rio Porce, R. Cauca tributary, Colombia, July 19, 1938) agree with Forel's description in general. The head of the worker is 1.1 times longer than broad, the occipital margin distinctly impressed, the anterior clypeal margin convex, the eyes 0.02 mm. in diameter, the mandibles with four well developed teeth arranged, however, on an oblique border, and the antennae 8-segmented with the scapes failing to reach the occipital corners by about their distal diameters. In side view the anterior pronotal margin is concave, the mesonotum is only feebly convex and the meso-epinotal impression is indistinct. The basal and declivous surfaces of the epinotum in side view are joined in a rounded angle. The petiolar scale in side view is thin, with a feebly convex anterior and a feebly concave posterior surface; from above and in front the dorsal surface is convex.

The female head, excluding mandibles, is rectangular, 1.1 times longer than broad, with occipital and anterior clypeal margins, subparallel sides, 4-toothed mandibles and 8-segmented antennae. The eyes are distinctive, being large, flattish, and situated less than a third their diameters from the mandibular insertions.

The undescribed male is 1.7 mm. long (thorax 0.5 mm.) has falcate mandibles with a single apical tooth and 9-segmented antennae. The petiolar scale is thin and conic in side view. The head is a dirty, dark brown, the gaster paler and the thorax still paler. The pubescence is moderately abundant and the hairs scanty.

The eggs are elliptical except for being slightly narrowed at one end and are  $0.43 \times 0.24$  mm. (fig. 11). The larvae are moderately slender and have numerous hairs, some of which are simple, some trifid and some flattened and finely divided apically; these are lacking at the sutures (fig. 6).

This species was found twice at the El Hormiguero Mine, Rio Porce. Workers were taken July 19 from rotted wood in the base of a hollow stump 2 meters high but with only a shell 2-5 cm. remaining. About two-fifths of the sides were gone, leaving a protected area open to the north. The stump stood on the open, grassy area close to the Rio El Hormiguero, a small creek. In cells in the rotted wood from ground level to 15 cm. below were various ant colonies (*Anochetus*, *Prionopelta punctulata* Mayr, a female *Camponotus* (*Myrmobrachys*) *lindigi* Mayr, tiny myrmicines, and the *Rhizomyrma*). Termites, spiders and snails were also present. Later in the day a second colony was found a mile or two away but on an almost vertical slope in a ravine with densely wooded slopes. These ants were in wet clay (a disintegrated granite rich in feldspar) at a place with a slope of  $70^{\circ}$ - $90^{\circ}$ . The *Rhizomyrma* had formed innumerable tunnels of varying diameter up to 2 mm. On roots of ferns and small herbs piercing the tunnels were pastured coccids of the type tended by *R. berwicki* in Trinidad. Coccids and ant brood were just below the surface to 5 cm. depth. The coccids could be seen to flip their "tails" up and down as do those associated with Trinidad

species. The ants were comparatively active in their movements. In the tunnels were found many males, a few alate females and many pupal females. No queen was seen. The tunnels completely surrounded those of *Strumigenys*, *Pheidole* and colonies of a minute myrmicine.

### **Acropyga (Rhizomyrma) dubitata** Wheeler and Mann

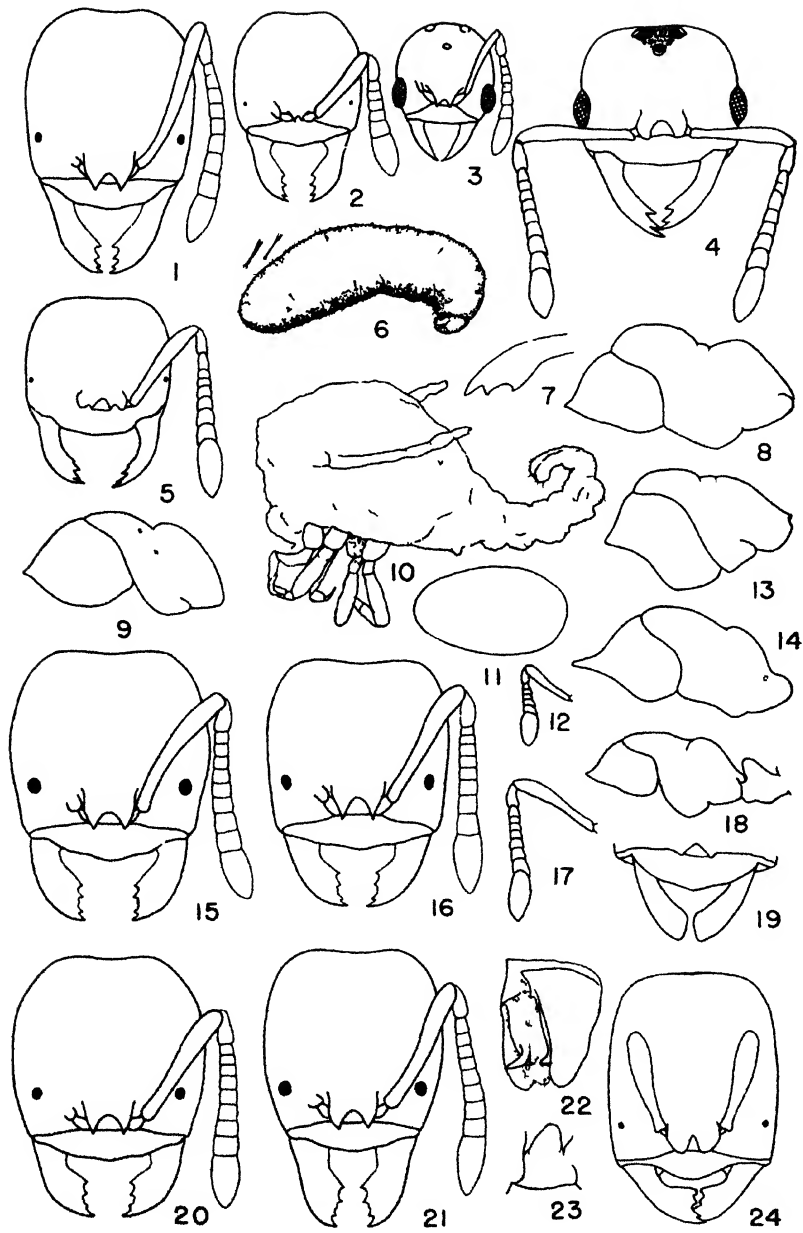
1914. *Rhizomyrma dubitata* Wheeler and Mann, Bull. Amer. Mus. Nat. Hist., 33: 47 (male).  
 1925. *Acropyga (Rhizomyrma) dubitata* Emery, Genera Insectorum, Fasc. 183, p. 29 (male).  
 1933. *Acropyga (Rhizomyrma) dubitata* Borgmeier, Rev. Ent., 3: 263 (male).  
 1935. *Acropyga (Rhizomyrma) dubitata* Wheeler, Jour. New York Ent. Soc., 43: 328 (male).  
 1936. *Acropyga (Rhizomyrma) dubita* Donisthorpe, Entomologist, 69: 110 (male).  
 1939. *Acropyga (Rhizomyrma) dubita* Donisthorpe, Proc. Ent. Soc. London, 8: 154 (male).

**Male.**—"Length 2 mm. Very similar to the male of *Acropyga*. Head a little broader than long, subrectangular. Eyes rather small, less than half as long as the sides of the head. Mandibles slender, distinctly tridentate. Clypeus convex and almost carinate in the middle, with entire, rounded anterior border. Antennae with long scapes, which reach well beyond the posterior corners of the head; first funicular joint globular, as broad as long, joints 2-7 a little broader than long, remaining joints longer. Thorax robust but not much broader than the head through the eyes. Mesonotum convex in front, slightly overarching the pronotum; scutellum not convex; epinotum rounded, sloping, without distinct base and declivity. Petiole with erect node, which is rather thick though compressed anteroposteriorly, with a blunt, rounded, entire border. Its anterior face in profile is slightly convex, its posterior face more flattened. Gaster rather short and stout; external genital valves large, with broad, bluntly bidentate tips; inner valves shorter, unciform. Wings rather large, like those of *Acropyga* with one cubital cell, no discoidal cell and the radial cell closed.

"Body shining throughout and very finely shagreened. Hairs

### EXPLANATION OF PLATE

FIGURE 1. *Acropyga (Rhizomyrma) guianensis*, sp. nov. Worker head. 2. *Rh. urichi*, sp. nov. Worker head. 3. *Rh. urichi*, sp. nov. Male head. 4. *Rh. rugersi* Bünzli. Female head of B. Guiana Colony 340. 5. *Rh. quadriceps*, sp. nov. Worker head. 6. *Rh. fuhrmanni* Forel. Mature larva with two of its hairs enlarged at left. 7. *Rh. trinitatis*, sp. nov. Worker mandible. 8. *Rh. trinitatis*, sp. nov. Worker thorax in side view, Cotype. 9. *Rh. donisthorpei*, sp. nov. Worker thorax in side view. 10. Sketch of Coccid tended by *Rh. berwicki* Wheeler type colony. 11. *Rh. fuhrmanni* Forel. Egg from Colombia Colony 996. 12. *Rh. kathrynae*, sp. nov. Worker antenna. 13. *Rh. mesonotalis*, sp. nov. Worker thorax in side view. 14. *Rh. goldii* Forel. B. Guiana Colony 576, worker thorax in side view. 15. *Rh. paludis*, sp. nov. Worker head. 16. *Rh. oko*, sp. nov. Worker head. 17. *Rh. trinitatis*, sp. nov. Worker antenna. 18. *Rh. trinitatis*, sp. nov.? Worker thorax and petiole in side view. 19. *Rh. trinitatis*, sp. nov.? Abnormal worker mandibles and clypeus. 20. *Rh. donisthorpei*, sp. nov. Worker head, B. Guiana Colony 474. 21. *Rh. donisthorpei*, sp. nov. Worker head, B. Guiana Colony 357. 22. *Rh. berwicki* Wheeler. Genitalia of male type colony. 23. *Rh. rugersi* Bünzli. Petiole of female of B. Guiana Colony 340. 24. *Rh. panamensis*, sp. nov. Worker head.





pale, erect, absent on the thorax and anterodorsal portion of the gaster, conspicuous on the petiole, venter and genitalia. Pubescence whitish, fine and rather dense, but not concealing the shining surface. Yellow throughout; appendages scarcely paler; only the ocellar triangle blackish or fuscous. In some specimens the body is very slightly tinged with brown. Wings yellowish gray, with colorless veins and stigma." (Wheeler and Mann).

*Type Locality*.—San Francisco Mts., San Domingo.

***Acropyga (Rhizomyrma) parvidens*, Wheeler and Mann**

1914. *Rhizomyrma parvidens* Wheeler and Mann, Bull. Amer. Mus. Nat. Hist., 33: 46-47 (worker).  
 1925. *Acropyga (Rhizomyrma) parvidens* Emery, Genera Insectorum, Fasc. 183, p. 30 (worker).  
 1935. *Acropyga (Rhizomyrma) parvidens* Wheeler, Jour. New York Ent. Soc., 42: 327, 328 (worker).  
 1936. *Acropyga (Rhizomyrma) parvidens* Donisthorpe, Entomologist, 69: 110 (worker).

*Worker*.—"Length 1.8-2 mm. Head subrectangular, a little broader than long, as broad in front as behind, with straight sides and a slight angular excision in the middle of the posterior border. Eyes minute, consisting of about 4 small ommatidia, situated at the anterior third of the head. Mandibles oblique but with distinct basal and apical borders, the latter with 4 small subequal teeth, much smaller than in any of the known species of the genus. Clypeus short and convex, with the anterior border entire, straight and transverse in the middle. Frontal area distinct, triangular; frontal and occipital grooves distinct. Antennae 10-jointed; scapes reaching to the posterior corners of the head; first funicular joint longer than broad, second joint small, as long as broad; joints 3-5 much broader than long, joints 7-8 as long as broad, terminal joint as long as the 3 preceding joints together. Thorax shaped much as in *R. göldii* Forel, but shorter and stouter, at least behind, where it is as broad as in front; seen from above the sides are rather concave in the middle; pronotum much broader than long, with less convex humeri than in *göldii*, mesonotum not longer than broad, as it is in *göldii*, fitting into the semicircular excavation of the posterior portion of the pronotum, convex and rising above the latter in profile, abruptly sloping behind to the meso-epinotal constriction which is pronounced but very short. Epinotum distinctly broader than long, in profile lower than the mesonotum, with rather straight base and declivity meeting at a rounded, obtuse angle, the base distinctly longer than the declivity. Petiole with an erect, well-developed scale, which is a little more than half as broad as the epinotum, but not as high, compressed anteroposteriorly, with flattened anterior and posterior surfaces and rather blunt, entire, broadly rounded superior border. Gaster rather large, elliptical. Legs stout.

"Body shining, finely shagreened and sparsely punctate. Mandibles and clypeus somewhat more opaque.

"Hairs and pubescence whitish or pale yellow, the former rather long, unequal, erect and confined to the body, the latter rather dense

and short, covering both body and appendages, but not obscuring the shining surface.

"Pale brownish yellow throughout; legs and antennae a little paler, head in some specimens a little darker, only the eyes and mandibular teeth brown." (Wheeler and Mann).

*Type Localities*.—Petionville and Diquini, Haiti.

***Acropyga (Rhizomyrma) marshalli* Crawley**

1921. *Acropyga (Rhizomyrma) marshalli* Crawley, Ann. Mag. Nat. Hist., 7: 93-95, fig. 2 (worker).  
1925. *Acropyga (Rhizomyrma) marshalli* Emery, Genera Insectorum, Fasc. 183, p. 30 (worker).  
1935. *Acropyga (Rhizomyrma) marshalli* Wheeler, Jour. New York Ent. Soc., 43: 327 (worker).  
1936. *Acropyga (Rhizomyrma) marshalli* Donisthorpe, Entomologist, 69: 110 (worker).

*Worker*.—Length 2 mm. Head, excluding mandibles, 1.2 times broader than long (according to figure), sides diverging anteriorly, occipital margin feebly impressed, anterior clypeal margin convex, feebly sinuate; eyes of 2-4 minute facets at anterior third of head; mandibles 3-toothed; antennae 10-11 segmented, the second funicular segment being only partly divided, scapes attaining occipital margin, funicular segments 3-7 broader than long, 8-9 barely broader than long; terminal segment equaling the 4 preceding taken together. Thorax broader than long, epinotum broader than long, in profile as high as mesonotum, the base rounded, the declivity feebly concave. Petiolar scale viewed from in front flat, straight along the top, sides diverging slightly, becoming broadest in middle of sides. Legs short and stout. Head subopaque, finely shagreened, thorax and gaster similarly shagreened but more shining. Head, antennae, legs and gaster covered with a fairly dense whitish pubescence; sparse long hairs on clypeus, posterior portion of pronotum and shorter hairs on mesonotum, base of mesonotum and margins of gastric segments. Pale yellow, some specimens slightly darker. (Crawley).

*Type Locality*.—Barbados, B. W. I. (J. R. Bovell No. 346).

Recorded in soil around a sugar cane root.

***Acropyga (Rhizomyrma) wheeleri* Mann**

1922. *Acropyga (Rhizomyrma) wheeleri* Mann, Proc. U. S. Nat. Mus., 61: 52-53 (worker, female).  
1925. *Acropyga (Rhizomyrma) wheeleri* Emery, Genera Insectorum, Fasc. 183, p. 30 (worker, female).  
1935. *Acropyga (Rhizomyrma) wheeleri* Wheeler, Journ. New York Ent. Soc., 43: 327-328 (worker, female).  
1936. *Acropyga (Rhizomyrma) wheeleri* Donisthorpe, Entomologist, 69: 110 (worker, female).

*Worker*.—Length 1.5 mm. Head subrectangular, a little longer than broad, occipital margin shallowly excised; mandibles 3-toothed, basal and apical borders distinct; eyes of one facet; antennae 9-segmented, scapes attaining occipital border, first funicular segment as long as second and third taken together, segments 2-5 strongly transverse, segments 6-7 about as long as broad, terminal segment nearly as long as the three preceding segments taken together. Pro-

notum broader than long, mesonotum longer than broad and about as long as pronotum. Base of pronotum more than twice as broad as long at middle, rounding gradually into declivous surface. Petiolar scale flattened, dorsal border rounded. Shining, hairs very fine, short and abundant on head, longer and sparser on body. Pale brownish yellow with brown mandibular teeth. (Mann).

*Female*.—Length 2 mm. Head shorter than in worker, second funicular segment longer than broad and segments 4-5 less transverse than in worker. Petiolar scale rather thick in profile. (Mann).

*Type Locality*.—Lombardia, Honduras.

Workers and a female (No. 1142) which I took on Barro Colorado Island, Panama Canal Zone, August 13, 1938, agree well with Dr. Mann's description except in larger size and with longer funicular segments. Both castes have 3-toothed mandibles and 9-segmented antennae; one worker has 8-segmented antennae on one side and 9-segmented on the opposite side.

The ants were taken in soil chambers around a nest of *Sericomyrmex amabilis* Wheeler. Both nests were in Quadrate 1 of the *Anacardium* tree being studied by Doctors Park, Voth and Williams, at a distance of 60 cm. from the base of the tree in luxuriant rain forest. Unfortunately there was time for no other observations.

### *Acropyga (Rhizomyrma) pickeli* Borgmeier

1927. *Acropyga (Rhizomyrma) pickeli* Borgmeier, Bol. Mus. Nac. Rio de Janeiro, 3:287 (worker) (not seen).
1927. *Acropyga (Rhizomyrma) pickeli* Pickel, Chacaras E Quintaes, 36: 592 (worker).
1927. *Acropyga (Rhizomyrma) pickeli* Pickel, *Rhizoecus Lendae*, n. sp., Imprensa Industrial, Recife, p. 27 (worker).
1928. *Acropyga (Rhizomyrma) pickeli* Costa Lima, Relatorio Sobre A Doença Dos Cafeeiros Em Pernambuco. Imprensa Official, Rio de Janeiro. p. 23.
1931. *Acropyga (Rhizomyrma) pickeli* Borgmeier, Rev. Ent., 1: 105-6 (worker).
1931. *Acropyga (Rhizomyrma) pickeli* Costa Lima, Bol. Biol., Fasc. 17, pp. 2-7, figs. 2-10, 12 (worker, female wing).
1932. *Acropyga (Rhizomyrma) pickeli* Costa Lima, Bol. Biol., Fasc. 21, pp. 65-69 (worker).
1933. *Acropyga (Rhizomyrma) pickeli* Borgmeier, Rev. Ent., 3: 263 (worker, female and male wing).
1935. *Acropyga (Rhizomyrma) pickeli* Wheeler, Jour. New York Ent. Soc., 43: 322-9 (worker, female, male).
1936. *Acropyga (Rhizomyrma) pickeli* Costa Lima, Terceiro Catalogo Dos Insectos Que Vivem Nas Plantas Do Brazil, Rio de Janeiro, p. 182 (worker).
1936. *Acropyga (Rhizomyrma) pickeli* Donisthorpe, Entomologist, 69: 110 (worker, female, male).

*Worker*.—Length 2-2.2 mm. Head, excluding mandibles, broader than long, occipital margin impressed, sides convex, rounding broadly into the occiput, anterior clypeal margin truncate or feebly convex; eyes minute; mandibles 4-toothed, the basal tooth being minute; cutting margin more oblique than in *decedens*; antennae 10-11 segmented, scape distinctly not reaching occipital angles. Color yellow. (Borgmeier).

*Female*.—Length 2.8 mm. Head, excluding mandibles, squarish; mandibles 4-toothed; antennae 11-segmented. Pale yellow.

*Male*.—Length 1.3-1.6 mm., antennae 9-segmented. (Donisthorpe).

*Type Localities*.—Parahyba do Norte and Pernambuco, Brazil. Also known from Surinam.

This species cultivates coccids on the roots of coffee. The ants transport the coccids from place to place and excavate a labyrinth of galleries for this purpose. Winged females disseminate the coccids by carrying them on the nuptial flight. The coccids and ants are thus enabled to spread widely. For further information on these ants the works of Pickel and Costa Lima may be consulted.

### ***Acropyga (Rhizomyrma) bruchi* Santschi**

1929. *Acropyga (Rhizomyrma) bruchi* Santschi, An. Soc. Cient. Argentina, 107: 38 (of reprint) (worker).  
1935. *Acropyga (Rhizomyrma) bruchi* Wheeler, Jour. New York Ent. Soc., 43: 327 (worker).  
1936. *Acropyga (Rhizomyrma) bruchi* Donisthorpe, Entomologist, 60: 110 (worker).

*Worker*.—Length about 2 mm. Head broader than long, sides straight or a little convex, occipital margin straight, anterior clypeal margin straight; eyes small, of one or two facets, situated a little in front of anterior third of sides; mandibles 3-toothed, the apical double the length of the basal tooth, teeth on a cutting margin forming an angle with the inner margin of mandibles; antennae 9-segmented, scape scarcely attaining occipital margin, second funicular segment scarcely as long as 3-5 taken together; 2 and 7 as long as broad, 3-5 about  $1\frac{3}{4}$   $1\frac{1}{2}$  broader than long, terminal segment a little longer than the three preceding taken together. Pronotum shorter, more convex and more "abrupt" than in *göldii*, mesonotum a little more convex, metanotum a little narrower. Petiolar scale vertical, thin, the dorsal border feebly convex, blunt. Shining, no erect hairs on thorax, very scattered on gaster, pubescence abundant. Pale yellow. (Santschi).

*Type Locality*.—Rosario de Santa Fe, Argentina.

This species is recorded merely as a "coccidophile."

### ***Acropyga (Rhizomyrma) paramaribensis* Borgmeier**

1933. *Acropyga (Rhizomyrma) paramaribensis* Borgmeier, Rev. Ent., 3: 263 (worker, female, male).  
1934. *Acropyga (Rhizomyrma) paramaribensis* Borgmeier, Arq. Inst. Biol. Veget. Rio de Janeiro, 1: 109-110, figs. 8-9, Pl. 1; figs. 1, 4, Pl. 2, figs. 1-2 (worker, female, male).  
1935. *Acropyga (Rhizomyrma) paramaribensis* Bünzli, Mitteil. Schweiz. Ent. Ges., 16: 453-593, 51 figs. (worker, female).  
1935. *Acropyga (Rhizomyrma) paramaribensis* Wheeler, Jour. New York Ent. Soc., 43: 327-8 (worker, female, male).  
1936. *Acropyga (Rhizomyrma) paramaribensis* Donisthorpe, Entomologist, 69: 110 (worker, female, male).

*Worker*.—Length 1.8 mm. Head, excluding mandibles, approximately as broad as long, occipital margin distinctly impressed, sides subparallel, rounding broadly into occiput; eyes minute, of 3-4 facets, situated on the anterior fourth of the head; mandibles 3-4 toothed, apical the largest; antennae 7-8 segmented, scape short, extending about three-fifths the distance to the occiput, second funicular segment may be divided (in the 8-segmented form); terminal segment

longer than the preceding four taken together (in the 8-segmented form). Thorax broader anteriorly than posteriorly, in profile with slightly concave pronotum, distinct pro-mesonotal impression, moderately convex mesonotum, two impressions in the meso-epinotal region and epinotum convex with a declivous surface much longer than the basal. Petiolar node inclined forward, anterior face in profile convex, apex somewhat pointed, posterior face feebly convex.

Moderately shining, finely shagreened. Pubescence pale yellow, abundant; pilosity erect, short. Color yellow, teeth infuscated. (Borgmeier).

*Female*.—Length 2.5 mm. Head, excluding mandibles, slightly broader than long, occipital margin distinctly impressed, sides subparallel, anterior clypeal margin convex; eyes large, convex, situated closer to the mandibular insertions than their diameter; mandibles 3-toothed; antennae 7-9 segmented, first funicular segment a little longer than the second. Epinotum abrupt, basal face extremely short. Wing 2.5 mm. (Borgmeier).

*Male*.—Length 2.2 mm. Head, excluding mandibles, broader back of eyes than long, occipital margin impressed, anterior clypeal margin convex; eyes very large, convex; mandibles 3-4 toothed, the teeth large and acute; antennae 10-segmented, scape not quite attaining the occipital corners. (Borgmeier).

*Type Locality*.—Paramaribo, Surinam.

These ants were taken by Bünzli from the roots of Liberian coffee where they were tending the coccids previously mentioned. His observations began early in 1931 and on April 16 winged females were taken on the surface of the ground. After a series of rainy days at 9 A. M. one morning he found three winged females, each carrying a small coccid (*Rhizococcus coffeae*) between her mandibles.

In 1932 (January 16 and 26, February 4 and 8) he found females flying with coccids at heights of 3-7 meters both in the morning 8-10 A. M.) and early afternoon (2-3 P. M.).

*Rhizomyrma rutgersi* females which occurred in the same locality were not observed to carry coccids.

For further information on the biology of this species Bünzli's paper may be consulted.

A female of this species was taken in virgin rain forest bordering the Oko River, a short tributary of the Mazaruni River, British Guiana June 26, 1936, by myself. The ant was found in a small tunnel at the base of the turret entrance to the nest of the fungus-growing ant, *Trachymyrmex phaleratus* Wheeler. The ants nested in heavy clay soil and there was no cultivated coffee or cacao for many miles.

### *Acropyga (Rhizomyrma) rutgersi* Bünzli

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1935. *Acropyga (Rhizomyrma) rutgersi* Bünzli, Mitteil. Schweiz Ent. Ges., 16: 453-593, 51 figs. (worker, female, male).

1936. *Acropyga (Rhizomyrma) rutgersi* Donisthorpe, Entomologist, 69: 110 (worker, female, male).

*Worker*.—Length 2.4-3.2 mm. Head in front view, excluding mandibles, in Bünzli's Abb. 12J and Abb. 8A is 1.1 times broader than

long, in his Abb. 12K it is 1.1 times *longer* than broad, anterior clypeal margin straight in Abb. 12J, feebly convex in Abb. 12K; mandibles 3-4 toothed, in Abb. 8A mandible with two teeth and a median denticle, in Abb. J-K with three distinct teeth; antennae 9-11 segmented, scape in Abb. 8A distinctly not reaching occiput and the second funicular segment is partially divided so that the antenna has 10 complete segments. (Bünzli).

*Female*.—Length 3.6-4.8 mm. Head in front view, excluding mandibles, in Bünzli's Abb. 8B is 1.14 times broader than long, occipital margin straight; one eye in the figure is higher than the other and both are convex; mandibles with three well developed teeth; antennae 10-11 segmented, the respective lengths of the scapes in the figure are 26.5 and 28 mm. so that the scapes either extend to the occiput or beyond it. (Bünzli).

*Male*.—Length 2.8-3 mm. Mandibles 3-toothed, antennae 12-segmented. (Bünzli).

*Type Locality*.—Paramaribo, Surinam.

If the drawings of worker heads in Bünzli's paper are accurate, the proportions of his figures J and K are those of different species. On the supposition that the figures are not all accurate I have identified a colony which I collected at Macuto, near La Guaira, Venezuela, as this species. In this colony (No. 673, August 16, 1936) the worker is 2.5-2.8 mm. long, has the head as broad as or slightly broader than long, (1.1 : 1), the anterior clypeal margin is convex, the mandibles are 3-toothed and the antennae 10-segmented. The female, 3.9 mm. long, has the head 1.1 times broader than long, the occipital margin straight, the mandibles 3-toothed and the antennae 11-segmented. The male, 2.5 mm. long, has 3-toothed mandibles and 12-segmented antennae.

Other collections, of females, made in Trinidad and British Guiana (Nos. 196.2, 255, 340) appear to be of this species though when typical specimens of *ruigersi* are available they may prove to belong to a new subspecies. They have the following characters:

No. 196.2—Rio Claro, Trinidad, 16. vi. 1935, 3.3 mm. long, head 0.62 x 0.57 mm., rest as in No. 340.

No. 255—Imperial College of Tropical Agriculture, Trinidad, 3. viii. 1935, 3.2 mm. long, head 0.65 x 0.58 mm., rest as in No. 340.

No. 340—Forest Settlement, Mazaruni R., British Guiana, 29. viii. 1935. Length 3.4 mm. (of thorax 1.0 mm.), head in front view broader than long, 0.66 x 0.59 mm., mandibles 3-toothed, antennae 11-segmented.

One more collection, of a colony (No. 286) from British Guiana (Forest Settlement, Mazaruni R., 17. viii. 1935), is evidently of *ruigersi* but may also prove to be a new subspecies unless *ruigersi* is unusually variable. These ants have the following characters:

*Worker*.—Length 2.2-2.8 mm. (of thorax 0.5-0.6 mm.), average 2.5 mm. Head in front view, excluding mandibles, slightly broader than long, mandibles 3-toothed; antennae 10-segmented, in one worker 9-segmented with a partially formed tenth segment, scapes extending to the occiput. Differing chiefly from the Venezuelan specimens of *R. ruigersi* (q. v.) in smaller size, narrower head, shorter scapes and duller, dirtier yellow color.

*Female* (Deälate).—Length 3.9 mm. (of thorax 1.0 mm.). Head in front view, excluding mandibles, 1.15 times broader than long; mandibles 3-toothed, antennae 11-segmented. Differing from the female of No. 340 chiefly in having a broader head and paler and duller color, the brown ocellar blotch being especially paler.

*Male*.—Length 2.4 mm. (of thorax 0.86 mm.). Mandibles 3-toothed, the apical being separated by a greater diastema than that between the middle and basal teeth which are also much smaller; antennae 12-segmented, the scapes exceeding the occipital corners by a third their lengths.

*Biology*.—The important studies of Bünzli (Bünzli, 1935) are summarized in the beginning of this paper and deal with this species and *R. paramaribensis* (q. v.). His paper should be consulted for the complete account. *R. rutgersi* tends coccids on the roots of Liberian coffee and Bünzli concluded that the ants are obligate coccidophiles. The swarming of this species was not observed but Bünzli was convinced that its habits were essentially similar to those of *R. paramaribensis*.

My Venezuelan specimens were taken from their nest at the base of a banana clump up the river valley  $\frac{1}{2}$ –1 mile back of the village. The bananas grew at a point where a reservoir emptied from the side into the stream bed and produced a small, wet area in an otherwise semi-arid region. The soil was an alluvium of sandy clay, gray-brown in color. The *Rhizomyrma* nest was in small chambers in the soil about a nest of the fungus-growing ant, *Acromyrmex octospinosus* Reich. In a blind pocket several centimeters beneath the surface about a dozen tiny coccids, unlike the common Trinidad form in habitus, and two or three large, plump coccids were found with ants. Coccids were also pastured on roots leading to the banana clump. The coccids were carried by the ants grasping them in the middle of the body, long axis parallel with that of the ants, but not always with the dorsal side uppermost. The coccids folded their legs when being transported. Ant eggs and coccids occurred in several chambers. Many winged females and males were in several chambers and one male took flight, indicating that he was mature. The soil 1–6 cm. down was permeated by the ant tunnels. No cacao was noticed in this area but there were in the vicinity what may have been young coffee plants.

The Guiana females (No. 340) were taken as they flew west just before and after sunset around 6 P. M. from the direction of a savannah area bordering the Mazaruni River towards the high rain forest a few rods from where I captured them. On this morning as well as on the previous day it had been raining heavily. The evening, however, was clear and calm. The ants pursued a steady course 5 to 7 feet above the ground and it was at once apparent that each was carrying a gleaming white object in her jaws. Upon capture each was found to be carrying a plump coccid by grasping the dorsum just back of the carapace and between the legs of the ants. The females flew near zigzagging swarms of small male ants of this species but were not seen to enter these swarms. They may have mated earlier.

The female taken near Rio Claro, Trinidad, flew into our touring car as we passed through heavy rain forest in the late afternoon. It, too, was carrying a plump coccid in its jaws.

Only one female was seen at St. Augustine, Trinidad, but this was flying close to one of a number of swarms of male *Rhizomyrma* which may well be of this species. In the twilight and just preceding the setting of the sun (6-6:30 P. M.) fully a dozen swarms of the males were zigzagging at a height above ground of six inches to five feet. The swarms were dense, approximately columnar in form, one to several feet high and six inches to one foot in diameter. The solitary female flew a few feet from one of the swarms and was easily distinguished by her much larger size and bright yellow color. The males were small and dark with 3-toothed mandibles and 12-segmented antennae.

The Guiana colony (No. 286) was discovered hardly a mile east of the place where the Guiana females (No. 340) were flying and the latter seemed to have come directly from the more easterly locality. The colony was a few rods from the Mazaruni River in a grassy savannah and was found 10 cm. beneath the entrance to a nest of *Atta sexdens* ssp. *rubropilosa* Forel in yellowish sand. Colonies of *Cyphomyrma rimosus*, *Holcaponera*, *Pheidole* and other ants likewise occurred nearby in the sand heaped up by the *Atta* or in soil about the fungus gardens. No coccids were found with the few scattered *Rhizomyrma* workers taken this day, August 17. August 31 the site was revisited and after diligent searching in the yellowish sand in the same spot additional workers, two dealate females, males, brood and coccids were taken about the roots of grass (later determined by Miss Chase of the U. S. Dept. Agriculture as *Axonopus compressus* (Swartz) Beauv.). Brood and coccids were taken at depths of 6-15 cm. on the small roots or in chambers. Most of the coccids were in blind pockets with the brood but away from the roots. Some coccids, however, were taken directly on the roots. A black *Pheidole* worker carried off a live *Rhizomyrma* worker while other *Pheidole* carried *Rhizomyrma* brood.

*Axonopus compressus* is an important forage grass in the tropics. No damage from the ant-coccid association was obvious here, however, for the grass grew luxuriantly.

If *R. rugersi* and its coccids are not confined to coffee roots the problem of control is made much more difficult, for this grass, bananas and probably numerous other plants to which these insects might be attracted are widespread.

### **Acropyga (*Rhizomyrma*) berwicki** Wheeler

Figures 10, 22

1935. *Acropyga (Rhizomyrma) berwicki* Wheeler, Jour. New York Ent. Soc., 43: 321-329, fig. 1 (worker).  
1936. *Acropyga (Rhizomyrma) berwicki* Donisthorpe, The Entomologist, 69: 110 (worker).

*Worker*.—Length 1.5-1.8 mm. "Integument thin and collapsible. Head as long as broad, with nearly straight, parallel sides, broadly rounded posterior corners and feebly convex posterior border. Eyes minute but deeply pigmented, consisting of 6 or 7 unequal, indistinct ommatidia, situated at the anterior sixth of the sides of the head. Mandibles narrow, curved, with very oblique apical borders bearing four subequal, acute teeth, the basal tooth separated from the other three by a distinct diastema and in some specimens stouter and less



obliquely inserted. Clypeus rather short, convex in the middle, with broadly rounded anterior border. Frontal carinae small, rounded; frontal area distinct, impressed, subtriangular; frontal groove obsolete. Antennae 8-jointed; scapes not reaching the posterior border of the head by fully one-fifth of their length; first funicular joint as long as the two succeeding joints together; second joint slightly longer than broad, narrowed at the base; 3-6 distinctly broader than long, increasing gradually in size distally to the terminal joint which is swollen and somewhat longer than the three preceding together. Thorax very short, less than twice as long as broad, widest through the pronotum which is twice as broad as long, in profile rising posteriorly to the mesonotum which is small but convex, sloping posteriorly to the distinct but short meso-epinotal constriction; epinotum broader than long, broader behind than in front, in profile nearly as high as the mesonotum, with anteriorly rather abruptly convex base passing gradually into the longer, flattened, sloping declivity. Petiole short, convex ventrally, its scale erect, rather small and thin, though thicker at the base than at the superior border, which is blunt broadly rounded and much lower than the base of the epinotum. Gaster large and convex anteriorly as in the other species of the genus. Fore tarsi slightly dilated.

"Shining; mandibles smooth, with a few scattered, piligerous punctures; remainder of body very finely reticulate, or superficially shagreened.

"Pilosity and pubescence yellowish, short, erect or suberect, the former dense and abundant, especially on the head, merging with the pilosity which is much sparser and longest on the pro- and mesonotum and tip of gaster.

"Pale yellow throughout, except the mandibular teeth which are deep red or dark brown." (Wheeler).

*Type Locality*.—San Raphael, Trinidad, B. W. I.

The descriptions below are taken from the type colony which I visited with its discoverer, Mr. E. J. H. Berwick. Only workers were taken originally by Mr. Berwick.

*Worker*.—Length 1.3-1.8 mm. Antennal scapes in some are shorter than in Dr. Wheeler's figure and fail to reach the occiput by about twice their distal diameter. Basal teeth are also more reduced and the occipital impression more distinct. Of 44 workers, all had both right and left antennae 8-segmented and had 4-toothed mandibles.

*Female* (Undescribed).—Length 2-2.5 mm. Head in front view, excluding mandibles, slightly broader than long, sides sub-parallel, occipital margin convex; eyes large, situated closer to the mandibular insertions than their diameters; antennae 8-segmented, scapes reach a level with the posterior ocelli; mandibles 4-toothed, the basal tooth small and of variable development. Dull, densely pubescent, the hairs partly reclinate, partly upright. Head and thorax brownish yellow, remainder paler, mandibular teeth and ocellar area infuscated.

*Male* (Undescribed).—Length 1.4 mm., antennae of 19 males 8-segmented right and left, mandibles 4-toothed. Petiolar node from above twice as broad as long, sides convex.

May 31, 1935, a few months after my friend, Mr. Berwick, discovered the colony originally we visited the site together near San Rafael. He had discovered the workers in cylinders of soil taken from beneath cacao trees on a large cacao estate in connection with soil studies. The holes left in the soil by the removal of the cylinders were still visible and guided us to the exact site of the colony. Fifteen inches from the base of a cacao tree all castes and coccids were taken in the top inch of heavy clay soil. Females and males were in separate chambers about eight inches apart, with workers and coccids. These chambers were merely slight enlargements of the tunnels which ramified through the top inch or two of clay under a layer of cacao leaves. Coccids were found pastured on the cacao rootlets. Earthworms and other tunnelling animals were also present in the clay and were inimical to the ants in that their tunnelling activities tended to break up the ant tunnels. In places where the earthworms were abundant the ant tunnels were mostly deserted. The ants have weak mandibles and probably could not bite the earthworm cuticula to an appreciable extent.

Additional collections of this species were made in Trinidad as follows:

April 1, 1935—Basin Hill Forest Reserve (central part of island at 700 ft. above sea level). The ants occurred in second growth scrub forest called *lastro* and there was no cacao or coffee within hundreds of feet at the minimum or about a mile along a road. Coccids were pastured on the roots of herbs and other plants in deep shade at a depth of between one and two inches only. The workers sought to carry the coccids away. A winged female was found on my collecting kit some rods away.

May 11, 1935—Mt. St. Benedict, Northern Range, in stream flood debris under cacao.

May 12, 1935—Foothills north of Tunapuna, in tunnels immediately beneath soil surface under cacao. Soil a friable clay under humus and leaf mold. Tending coccids which "lashed" their tails in a vertical plane over their dorsal surfaces when they were disturbed.

June 18, 1935—A half mile up Tucuragua River, a tributary of the Tucarigua River, Northern Range. In rotted wood and humus under cacao.

April 28, 1935—Mason's estate just north of Arima. A colony with females, workers, brood and coccids nested in damp clay-loam alluvial soil under cacao, coffee, banana and *Immortelle* shade trees in a new section of the plantation. The cacao and *Immortelle* trees were old remnants. The ants and coccids were in small anastomosing tunnels in the upper few centimeters of soil. The coccids were in bare tunnels and probably they and the ants were "marking time" until the rains came so as to be able to get on juicy rootlets. All of the plantation was very dry except a small area adjacent to several watercourses.

The April 1st colony was collected with soil and placed in an observation nest. During the night of April 2 workers of a pest *Monomorium* invaded the nest and ate all the sugar syrup which was placed in the nest for the *Rhizomyrma*. The *Monomorium* were exterminated. By April 5 the colony had stabilized, the ants having gathered all brood and coccids in several tunnels which they had made in the soil. The

ants were, of course, strongly photophobic and could rarely be studied to advantage. April 18 they were moved to a better nest. April 25 a number of workers, one queen and larvae were found in a piece of clay which was broken up for examination. The larvae were attached to the sides of the tunnels by their hairs. April 30 a worker, when I examined the nest, waved its antennae in my direction as though it saw me; the nest was glass-covered. May 20 the colony, upon breaking the soil up, was found to be dead. Young and adult cheese mites were moving in masses through the tunnels.

The May 12 colony was also collected and placed in an observation nest. They also tunneled into the soil. Under a binocular the colony was watched May 21. A large coccid with bifurcated "tail" excreted a clear droplet on the dorsum of the "tail" at the base of the bifurcation where there was a tuft of long hairs. It was disturbed by the light and wandered awkwardly about with the "tail" held horizontally. An ant, ignoring the droplet, finally grasped it by its dorsal surface at the "carapace" and carried it down a tunnel. All the coccids, large and small, were similarly carried away with the long axis parallel to that of the ant and head end forward.

#### ***Acropyga (Rhizomyrma) robae* Donisthorpe**

1936. *Acropyga (Rhizomyrma) robae* Donisthorpe, *Entomologist*, 69: 108-111, figs. 1-3 (worker, female, male).

*Worker*.—Length 2.3 mm. "Pale yellow, apex of mandibles and teeth reddish-brown, eyes brown, whole body clothed with longer and shorter, erect or sub-erect, pale yellow hairs, extremely finely and closely punctured.

"Head subrectangular, about as long as broad, sides feebly rounded, posterior border slightly emarginate; eyes very small, consisting of about three facets, situated on the sides of the head about a quarter of the length of the head from anterior border; mandibles narrow, curved, armed with three pointed teeth, the apical one being the longest; clypeus convex, rounded in front; frontal area distinct, moderate, triangular; frontal furrow not present; frontal carinae moderate, bisinuate; antennae 8-jointed; scape curved, not quite reaching the posterior corners of the head when bent back; funiculus increasing in breadth to apex, first two joints elongate, third and fourth transverse, fifth and sixth as long as broad, last joint pointed, as long as the three preceding taken together. Thorax robust, not quite as long as the head and mandible taken together; pronotum transverse, rounded at sides; mesonotum convex, higher than pronotum, suture between distinct; meso-epinotal suture somewhat deep, well defined; epinotum convex round, sloping gradually to the declivity, which is longer than the dorsal region. Petiole short, furnished with a node which is pointed above, the anterior surface flat, the posterior surface slightly concave; gaster rather long and bulky, pointed at apex. Legs moderate, not very slender." (Donisthorpe).

*Female*.—"Length 3.4 mm. Pale yellow, apex of mandibles and teeth reddish-brown, eyes, ocelli and a spot at insertion of fore wing black. Larger, but with structure, etc., except the usual differences,

much as in the worker. The mandibles and apical tooth are longer; eyes and ocelli well formed; wings somewhat dusky, one cubital cell, no discoidal cell, radial cell closed." (Donisthorpe).

*Male*.—"Length 2.3 mm. Smaller than the female, dirty brownish yellow, head blackish. Eyes large; ocelli moderate; mandibles thin, curved, with an angulation near apex (but no teeth); apical tooth pointed; antennae 10-jointed; node of petiole rather large, rounded above, anterior and posterior surfaces flat. Wings as in female." (Donisthorpe).

*Type Locality*.—La Esperanza, Colombia.

The colony was taken associating with a small coccid at the roots of coffee in April, 1935.

***Acropyga (Rhizomyrma) borgmeieri* Donisthorpe**

1939. *Acropyga (Rhizomyrma) borgmeieri* Donisthorpe, Proc. Ent. Soc. London, 8: 153-4 (male).

*Male*.—"Length 2.2 mm. Pale brownish-yellow, head somewhat darker, legs and antennae lighter, very finely punctured, shining, clothed with decumbent pubescence, especially on the gaster, and longer and shorter, suberect hairs. Head transverse, evenly rounded from behind eyes to posterior border, posterior border very slightly sinuate in centre; clypeus transverse, convex, anterior border evenly rounded; frontal area distinct; frontal furrow shallow, reaching median ocellus; eyes large, hemispherical, projecting, occupying nearly half the side of the head; ocelli moderate; mandibles slender, arched, with three teeth to the masticatory border; antennae 12-jointed, fairly long, scapes extending a little beyond posterior angles of head, funiculus with 1st joint triangular, about as broad as long, broader than joints 2-7, which are transverse, the rest longer, last joint a little longer than the two preceding taken together. Thorax convex; mesonotum rounded anteriorly, over-reaching the pronotum; scutellum transverse, slightly convex; epinotum convex, rounded without marked declivity; petiole nodiform, with a blunt rounded point above, slightly convex anteriorly, concave posteriorly and narrowly margined; gaster with genitalia somewhat elongate; external genitalia very large and prominent, stipes long, curved and furnished with a triangular hook, volsellae short and hooked, sagittae narrow with blunt turned-up apex. Wings translucent, covered with minute hairs, pterostigma and veins pale brownish-yellow, no discoidal cell, one cubital cell and closed radial cell." (Donisthorpe).

*Type Locality*.—Forest Settlement, Mazaruni R., British Guiana.

***Acropyga (Rhizomyrma) mesonotalis*, sp. nov.**

Figure 13

*Worker*.—Length 1.8-2.1 mm. (of thorax 0.5-0.6 mm.). Head in front view, excluding mandibles, as broad as long or very slightly broader, occipital margin distinctly impressed, sides convex and rounding broadly into the occiput, anterior clypeal margin feebly convex; eyes small, 0.03-0.04 mm. in diameter, situated on the

anterior fourth of the sides of the head; mandibles 4-toothed, the teeth situated on an oblique cutting border and progressively decreasing in size from the large, acute apical tooth; antennae 9-10 segmented, the second funicular segment being in some specimens incompletely or completely divided, scapes slightly exceeding occipital corners. Thorax in side view characterized by a high mesonotum and an almost evenly convex epinotum whose basal and declivous margins are indistinctly separated; from above the pronotum appears lunate and is much wider than the epinotum, meso-epinotal region moderately impressed, the impression involving the posterior extension of the mesonotum. Petiolar node in profile sub-vertical with almost parallel anterior and posterior margins, the former being slightly convex, apex blunt; when viewed anteriorly the apex is truncate and the sides have prominent stigmata near the apex. Gaster elongate-ovate. Legs moderately short and slender.

Shining, densely and finely punctate. Pilosity of a short, appressed and somewhat thin pubescence, the individual hairs being clearly separated from one another; longer and upright hairs are sparse and distributed over the body, scapes and legs, being of irregular lengths and most abundant on the legs and gaster apically. Brownish yellow, head darker than rest of body and mandibular teeth infuscated.

*Female* (Deålte).—Length 3.4 mm. (of thorax 0.8 mm.). Head in front view, excluding mandibles, distinctly broader than long, occipital margin slightly concave, sides convex and rounding broadly into the occipital margin, anterior clypeal margin faintly angular; eyes moderately large, 0.06 mm. in greatest diameter, closer than their diameters from the mandibular insertions; mandibles 4-toothed, the teeth on an oblique cutting margin and all acute, apical much the longest and the basal slightly smaller than the median two; antennae 10-11 segmented, the second funicular segment being partially divided. Thorax in side view with pronotum and mesonotum rising almost vertically together at their anterior margins, epinotum feebly convex, petiolar scale in profile thin, anterior and posterior margins nearly straight, less parallel than in the worker, apex truncate. Legs moderately short and slender.

Shining, densely and finely punctate. Pilosity and color as in worker, ocellar region with a brown blotch.

*Cotypes*.—Workers and a female of a colony (No. 727) with coccids which I took June 6, 1938, between Petionville and Kenscoff at an elevation of about 4500 feet in the Republic of Haiti. The coccids were tended by the ants on the roots of coffee in red clayey humus from the top of the soil to 4 cm. in depth.

Though *R. parvidens* is recorded from Petionville also, this species differs distinctly, when compared with the *parvidens* description, chiefly in having much larger teeth, the antennal scapes longer, the meso-epinotal impression longer, the epinotum more rounded in profile, the petiolar node truncate above, the body not shagreened and the pubescence thinner. This is the third species recorded from Hispaniola but the first taken with coccids.

***Acropyga (Rhizomyrma) panamensis*, sp. nov.**

## Figure 24

*Worker*.—Length 1.5 mm. (thorax 0.41 mm.). Head in front view, excluding mandibles, rectangular, 1.3 times longer than broad, occipital margin rounded, faintly impressed medially, sides widest apart at a level with the distal ends of antennal scapes, clypeal margin convex; eyes minute; antennae 8-segmented, short, the scapes fail to reach occipital corners by a distance equal to half their length, first funicular segment longer than 2-5 taken together, terminal segment  $0.18 \times 0.29$  mm., compressed; mandibles stout, 4-5 toothed, the basal tooth being broad and bifurcated on the right side making that mandible 5-toothed while the left basal tooth is similarly broad at the base but with only one cusp. Thorax from above 1.8 times longer than broad, two-thirds as broad through epinotum as through pronotum, moderately compressed in the meso-epinotal region; in side view rising steeply at the pronotum to a plane dorsal surface. Petiolar scale in side view thick, blunt at apex, anterior surface convex. Gaster elongate-ovate. Legs moderately short.

Shining, densely and finely punctate. Pilosity of a moderately abundant reclinate pubescence, a few scattered longer and upright hairs, especially about mouthparts and terminal gastric segments. Pale yellow, mandibles infuscated and head more intense yellow than thorax and gaster.

*Holotype*.—One worker (No. 922(27)) taken by Dr. E. C. Williams, Jr., on Barro Colorado Island, Panama Canal Zone. This is the species referred to as *Rhizomyrma* n. sp. (Williams, 1941, p. 79). The ant was probably among leaves on the forest floor.

***Acropyga (Rhizomyrma) quadriceps* sp. nov.**

## Figure 5

*Worker*.—Length 2.7-2.9 mm. Head in front view, excluding mandibles, quadrate, very slightly broader than long, occipital margin truncate, corners rounded, sides subparallel except converging behind, occipital margin feebly convex; eyes minute; antennae 10-segmented, scapes in most specimens not quite reaching occipital angles, in several workers they barely exceed the angles; mandibles 4-toothed, the basal tooth minute, the others much larger and well developed. Thorax in side view with feebly concave anterior pronotal margin, balance of pronotum and the mesonotum forming a distinct, convex lobe; meso-epinotal impression broad, deep and distinct; basal surface of epinotum short, convex, passing gently into the much longer and slightly convex declivous surface; from above broadest through pronotum, meso-epinotal region strongly constricted above. Petiole in side view conic with thick, blunt apex and straight posterior surface, crest evenly convex. Gaster ovate. Legs of moderate length.

Integument shining, finely punctate, collapsible in thorax and gaster. Pilosity of scanty long, upright hairs, more numerous but shorter upright hairs, and a fine, appressed pubescence most abundant

on head and gaster. Yellow with a brownish cast most apparent on head, mandibular teeth infuscated.

*Cotypes*.—Workers of one colony (No. 74) which I took March 23, 1935, near Maracas Waterfall in the Maracas Valley, Northern Range, Trinidad, B. W. I., at an elevation of 900 ft. These ants were taken within a few rods of the spot where the cotypes of *R. kathrynae* were taken. They were, however, not under trees but were found in the clay soil of the roadway in tunnels with coccids at depths of 2.5–8 cm. There were no roots in these tunnels and it is possible that heavy rains of the morning and preceding night may have forced them to this place from the adjoining forest. There were no cacao trees for hundreds of feet.

This species, compared with *R. pickeli* cotypes, is larger and with similar teeth. The occiput, however, is not impressed, the pubescence more abundant, and the pro-mesonotal impression less marked. They are closely related.

The colony was collected and placed in a small observation nest. The next morning the entire colony was hidden in a cell in a small pile of clay in a glass container placed in the nest. Some of the smaller coccids were outside the cell on moist soil. The following morning small coccids were still outside the ant cell but most had been carried in by the ants. March 26 there was no change in the appearance except that fungus had developed on banana and papaya fruit which I placed in the nest for food. March 27 the coccids had congregated at one place in the bottom of the cell, visible through the glass from below, and were tended by the ants. The ants were highly photophobic then as before. March 29 conditions were as before until the glass container was accidentally upset and ants and coccids fell out with the clay. The workers immediately grasped the coccids and buried into the soil. The next day all were together in a cell as before. March 31 the colony was alive but several coccids were alone. Between April 1 and April 18 the members of the colony gradually died. Evidently observation nests to be successful would require living plant roots to nourish the coccids who would in turn nourish the ants.

***Acropyga (Rhizomyrma) kathrynae*, sp. nov.**

Figure 12

*Worker*.—Length 1.2–1.3 mm. (of thorax 0.36–0.37 mm.). Head in front view, excluding mandibles, slightly longer than broad, 0.35 x 0.39 mm., distinctly impressed medially at occiput, sides slightly convex, anterior clypeal margin truncate; eyes small, about 0.02–0.03 mm. in diameter, situated at a distance from the mandibular insertions equal to about twice their diameters; mandibles stout, with four distinct teeth of which the basal is smallest, mandibles broadest through basal tooth; antennae 8-segmented, antennal scapes extend slightly over three-fourths the distance to the occipital corners. Thorax in side view with anterior pronotal margin concave and with convexities in pronotal-mesonotal and epinotal regions, the mesoepinotal region being slightly concave; from above the thorax is about twice as broad through the pronotum as through the basal surface of

epinotum, meso-epinotal region strongly constricted. Petiolar scale convex dorsally, in side view conic, compressed, the apex rounded. Gaster elongate-ovate with pointed apex. Legs moderately short and slender.

Integument shiny, thin and collapsible. Pilosity of scattered, irregular, upright hairs most numerous on thorax and gaster; abundant short, upright hairs chiefly on head and gaster; an appressed pubescence most abundant on head and gaster. Pale straw yellow, only the mandibular teeth infuscated.

*Cotypes*.—Workers of one colony (No. 76) which I took March 23, 1935, near Maracas Waterfall in the Maracas Valley, Northern Range, Trinidad, B. W. I., at an elevation of 900 ft. The ants, and several of this species taken March 19 at the same spot, were found among humus on the forest floor in a shady ravine. Growing nearby were cacao as well as other trees. This species, which is dedicated to my mother, is close to *fuhrmanni* but is smaller and with distinctly shorter antennal scapes.

Workers (Nos. 1172, 1178, 1185, 1187) which I took on Barro Colorado Island, Panama Canal Zone, agree closely with the cotypes. Several of the specimens are slightly larger (1.5 mm.) and slightly less impressed in the meso-epinotal region but all have similar head proportions, etc., and have the same pale, almost ivory, color of the thorax. They were taken on the same day, August 15, 1938. Workers were found in soil about the nest of *Cyphomyrmex costatus* Mann with its guest ant, *Megalomyrmex (Cepobroticus) wheeleri* Weber, which was under a small stone. Occupying the same runways with the *Rhizomyrma*, as well as adjacent and anastomosing chambers, were workers of a tiny yellow myrmicine. The second record was of *Rhizomyrma* workers close to a nest of *Cyphomyrmex costatus* Mann<sup>5</sup> but under a nearby stone. Both localities were on a rocky slope in luxuriant rain forest. The third and fourth records were both under rocks, one having tunnels anastomosing with those of a minute yellow myrmicine, the other similarly associated with a very small yellow ponerine ant.

### ***Acropyga (Rhizomyrma) urichi*, sp. nov.**

Figures 2, 3

*Worker*.—Length 1.5–1.9 mm. (of thorax 0.4 mm.). Head in front view, excluding mandibles, 1.1 times longer than broad, occipital margin distinctly impressed, sides convex and converging broadly to occiput, anterior clypeal margin convex; eyes minute, 0.02 mm. in diameter; mandibles 4-toothed, the basal tooth small and not greatly more distant from the third than the third is from the fourth; antennae 7–8 segmented, scapes short, failing to reach the occipital angles by about twice their distal diameter. Thorax in side view with concave anterior pronotal margin, distinct pro-mesonotal impression, flat dorsal surface which forms a distinct angle with the declivous surface of the epinotum; thorax from above one and two-thirds times longer than broad, strongly compressed in the meso-epinotal region. Petiolar scale with convex anterior and largely straight posterior surface, truncate at apex. Gaster elongate-ovate. Legs moderate.

<sup>5</sup>A photograph of the nest and site has appeared (Weber, 1941, Pl. 2).



Shining, finely punctate. Pilosity of a fine, appressed to reclinate pubescence which is most conspicuously abundant on the thorax and legs; with upright, longer and sparse hairs of variable lengths scattered generally over the body. Pale yellow, mandibular teeth infuscated.

*Female*.—Length 2.2 mm. (of thorax 0.7 mm.). Head in front view, excluding mandibles, 1.1 times longer than broad, occipital margin feebly convex, sides sub-parallel, anterior clypeal margin faintly convex, nearly straight; eyes large (0.11 mm.), situated much closer to the mandibular margin than their diameters; antennae 8-segmented, scapes failing to reach occipital angles by a distance about equal to their distal diameters, funiculi short, segments 3–5 as broad or broader than long. Petiole in side view cuneate, blunt and thick at apex, from above truncate apically. Gaster elongate, cylindrical. Legs moderate.

Shining, finely punctate. Pubescence on the head short, reclinate and abundant, on the thorax longer, more upright, on the gaster, longer, reclinate and abundant; appendages with abundant, long pubescence; pilosity of scattered, long, upright hairs. Head brown, ocellar region and mandibles infuscated; thorax, appendages and petiole light yellowish brown; gastric segments becoming dark brown posteriorly.

*Male*.—Length 1.8 mm. (of thorax 0.5 mm.). Head in front view, including mandibles, ovate; antennae 9-segmented; mandibles with a single long, acute apical tooth and a concave cutting margin which is separated from the inner margin by an obtuse angle. Epinotum in profile convex. Petiole thick, truncate at apex, the sides rounded. Wings hyaline, iridescent, with pale brown veins. Shining, finely punctate. Pilosity of a moderately abundant reclinate pubescence and sparse, upright, long hairs. Head and thorax brown, thorax and appendages pale brown.

*Cotypes*.—Specimens of all castes from two colonies (Nos. 438 and 440) which contained coccids and were 265 meters apart under cacao at the La Montserrat Estate, Maracas Valley, Trinidad, B. W. I., May 27, 1936. This species, which is dedicated to the late Mr. F. W. Urich, is close to *R. berwicki* but differs especially in having a narrower head and a plane dorsal surface of the thorax. The basal tooth of the mandible is closer to the other teeth and the antennal scapes are somewhat shorter.

*Biology*.—Colony 438 occurred under a cacao tree and 90 cm. from its trunk. The colony was surrounded by not only cacao but also banana and coffee, the nearest banana plant being 190 cm. and the nearest coffee tree 380 cm. distant. In an area with a diameter of 10 cm. were found nests of the termite, *Anoplotermes* sp., and ants of this *Rhizomyrma*, *Prionopelta*, and *Pheidole*, all having chambers or tunnels anastomosing with one another at depths of 2.5–7.5 cm. in reddish clay soil beneath a layer of leaf mold, largely from cacao leaves. Heavily shading this area were the cacao and Immortelle trees as well as numerous vines and herbs which were mostly about 20 cm. high. This valley has an annual rainfall probably of about 80 inches.

Two queens and most of the broad and coccids found were in a chamber at a depth of 7.5 cm. which lacked any roots. The tunnels

radiating out from the chamber were penetrated by roots which likely came, at least in part, from the nearby cacao tree and which supplied the food for the coccids. The termites and other ant colonies probably had no particular relationship with the *Rhizomyrma* and merely occupied the same habitat.

Colony 440 was 45 cm. from a cacao tree of the same plantation. The males and most of the brood and coccids were in clay 1-2 cm. from the surface while the workers and brood occurred still deeper to 8 cm. 185 cm. away was a coffee tree with green fruit and 160 cm. in the opposite direction was a smaller coffee tree. Coccids were found pastured on cacao roots close to the surface.

The same cacao tree was also suffering from the attacks of membracids which were tended on the cacao pods by *Azteca* ants. The ants erected carton sheds over the membracids, generally on the protected side touching the trunk of the tree. Other membracids were freely exposed but were similarly tended by these active, vicious and exceedingly aggressive ants which emit a sticky, offensive-smelling anal fluid of a whitish color. Under one *Azteca* carton shed on the cacao pod nearest the ground a flourishing colony of *Monomorium* with brood occurred, though the *Azteca* could easily have demolished the carton. Clearly they tolerated one another.

#### ***Acropyga (Rhizomyrma) trinitatis*, sp. nov.**

Figures 7-8, 17-19

*Worker*.—Length 2.2 mm. (of thorax 0.64 mm.). Head, excluding mandibles, squarish, between 1.0 and 1.1 times broader than long, occipital margin faintly impressed medially, sides feebly convex and rounding broadly into occiput, anterior clypeal margin feebly convex; eyes minute, 0.02 mm. in diameter, situated posterior to a level with the posterior margin of the frontal lobes; mandibles 3-toothed, the apical tooth large and acute, the basal teeth acute but much shorter, in some specimens all teeth greatly worn down to vestiges, teeth on a cutting margin which runs into the inner margin without forming a distinct angle; antennae mostly 10-segmented, occasionally 9- or 11-segmented, the loss of a segment or the adding of a segment taking place distal to the first funicular segment. Thorax in side view with pro-mesonotal and meso-epinotal sutures distinctly impressed, the anterior pronotal margin faintly concave; thorax from above one and two-thirds times longer than broad through pronotum, moderately impressed in the meso-epinotal region. Petiolar scale in side view inclined forward, anterior margin convex, posterior margin straight, apex blunt, rounded and with the dorsal margin convex when viewed from in front. Contracted gaster short-ovate. Legs of moderate length.

Shining, faintly punctate. Pilosity of a scanty short, appressed, pubescence on the head and a few long, upright hairs on the clypeus; thorax with a sparser pubescence. Pale yellow, mandibular teeth infuscated.

*Female*.—Length 2.6 mm. Head in front view, excluding mandibles, 1.1 times broader than long; mandibles with three blunt teeth

of which the apical and second are closest together; antennae 11-segmented. Head with a very few hairs; gaster with a more abundant pubescence and scattered hairs most numerous posteriorly.

*Cotypes*.—Workers and female of a colony (No. 108) which I took April 7, 1935, between the 11th and the 11¼ mile of the Arima-Blanchisseuse Road at an elevation of 1800 feet in the Northern Range, Trinidad, B. W. I. A worker and a winged female taken at this same spot (the same several square yards) March 28, 1935, probably belong to this species although the worker lacks even the vestiges of teeth and has 9-segmented antennae. The female is 3 mm. long, has the mandibles 4-toothed and in addition indications of one or two denticles, and has the antennae 9-segmented. This species is near *R. rutgersi* but comparison with the original figures of *rutgersi* is difficult because of their variability. From Venezuelan specimens ascribed to *rutgersi* this species differs in having much smaller eyes, smaller size and duller color.

*Biology*.—The ants were found in an area having an annual rainfall of about 120 inches and the surrounding rain forest contained tree ferns. The April ants were taken with coccids at a depth of about 3 cm. in damp clay under grass beside the road and close to a log. Brood and adults were in small chambers. The March worker was taken under this log while the winged female was found on it. The April 7 colony was taken back to the Imperial College and placed in a small observation nest with damp clay. The next morning the ants had tunneled into a piece of wet clay and had all gathered there. The marked photophobia of the ants was noted on this and successive days. April 11 several larvae and a coccid were preserved and the female was momentarily chloroformed in order to count the teeth and antennal segments. April 12 the female was alive and active while all the ants had gathered into a small cell in soaking wet clay. April 26 the colony was transferred to a Petri dish but observations were still difficult to make and by May 20 the ants had died. Fungi sprouted in numerous places on their bodies at the sutures. Long, threadlike hyphae on some terminated in yellow spherical clusters of conidia, other and shorter hyphae terminated in white spherical clusters.

A single worker was taken in humus at the base of bromeliads in low, dripping wet cloud forest on the summit of El Tucuché, 3072 feet, the second highest peak in Trinidad.

***Acropyga (Rhizomyrma) donisthorpei*, sp. nov.**

Figures 9, 20-21.

*Worker*.—Length 2.1-2.4 mm. (thorax length 0.55-0.57 mm.). Head in front view, excluding mandibles, 1.1 times longer than broad, occipital margin slightly impressed medially, sides and anterior clypeal margin moderately convex; eyes minute, about 0.03 mm. in diameter, situated at a level with the frontal lobes; mandibles 4-toothed; antennae 11-segmented, scapes failing to reach occipital angles by a distance equal to less than their distal diameter. Thorax in side view with strongly convex pro-mesonotum, the pro-mesonotal suture being feebly impressed, meso-epinotal impression deep, the

epinotum rising as a short convexity; from above thorax less than twice as broad as long, less than one and one-third times broader through pronotum than through epinotum, meso-epinotal region moderately impressed. Petiolar scale in side view blunt and feebly emarginate at apex, anterior margin convex, pedicel produced ventrally as a rounded lobe. Gaster elongate-ovate, legs moderately long and slender.

Shining, finely punctate. Pilosity of an abundant, comparatively long reclinate pubescence, and sparse, scattered, long, upright hairs. Brownish yellow, mandibles and clypeal margins infuscated.

*Cotypes*.—Workers of one colony (No. 474) which I took on Kartabo Point, between the Cuyuni and Mazaruni Rivers, British Guiana, June 15, 1936. The workers were found in wet, rotted wood of a log lying in high rain forest. When a sack of this wood and leafy humus with twigs from the upper surface of the log was examined at camp the ants were seen tending tiny, white coccids of the common Trinidad type on bright orange roots of some herb or vine. 22½ miles west of Kartabo Point on September 8, 1935, I took a worker of this species in humus from the rain forest floor on top of a white sand ridge.

This species is near *R. decedens*, *göldii* and *rutgersi*. It has shorter scapes than *göldii* and is darker, has a longer head than *decedens* with more distinct median occipital impression, and has a more distinct meso-epinotal impression than have the above species or *rutgersi*.

#### *Acropyga (Rhizomyrma) oko*, sp. nov.

Figure 16

*Worker*.—Length 1.7 mm. (of thorax 0.55 mm.). Head in front view, excluding mandibles, barely longer than broad, occipital margin broadly and distinctly impressed, sides convex and rounding broadly into the occipital corners, anterior clypeal margin feebly convex; eyes comparatively large (0.04 mm. diameter), situated less than three times their diameters from the mandibular insertions; mandibles 4-toothed, the basal teeth being small and widely spaced, mandibles distinctly broadest through the basal tooth; antennae 11-segmented, scapes failing to reach occipital angles by a distance about equal to their distal diameters, first funicular segment equal in length to 2-4 taken together, 3-9 transverse. Thorax in side view with concave pronotal anterior margin, strongly convex pro-mesonotum, protuberant spiracles in meso-epinotal region, the suture being distinctly impressed, basal surface and declivous surface of epinotum forming one even convexity; from above thorax nearly 1.6 times longer than broad, about 1.3 times broader through pronotum than through epinotum, sides moderately impressed in meso-epinotal region. Petiolar scale blunt at apex and feebly emarginate. Gaster elongate-ovate. Legs moderately long and slender.

Shining, finely punctate. Pilosity of an abundant long, reclinate pubescence and sparse, scattered, upright hairs. Pale brownish yellow, head darker, mandibular margins infuscated.

*Cotypes*.—Several workers of one colony (No. 481) which I took beside the Oko River, tributary of the Cuyuni River, about 37 miles

by trail from Kartabo Point, British Guiana, June 19, 1936. The ants were found in clay soil about a nest of *Myrmicocrypta unidentata* Weber which was itself in soil above a large nest of *Atta cephalotes* L.

*R. oko* is close to *R. donisthorpei* from which it differs chiefly in smaller size, larger eyes, shorter head and paler color.

**Acropyga (Rhizomyrma) guianensis sp. nov.**

Figure 1

*Worker*.—Length 2.3 mm. (of thorax 0.6 mm.). Head in front view, excluding mandibles, 1.2 times longer than broad (0.54 x 0.46 mm.), occipital margin broadly and distinctly impressed, sides and anterior clypeal margin convex, eyes 0.04 mm. in diameter, situated at that distance above a level with the posterior margin of the frontal lobes; antennae 10-segmented, scapes distinctly exceeding occipital angles, first funicular segment as long or longer than 2-3 taken together but shorter than 2-4, second funicular segment may or may not be partially divided by a suture; mandibles stout, with four stout teeth on a cutting margin which forms an obtuse angle with the inner margin, third tooth separated by a greater diastema than the others. Thorax in side view forming with the epinotum a convexity only slightly broken by the feebly concave anterior margin of pronotum, feeble pro-mesonotal and meso-epinotal impressions, and the slight angularity of the epinotum; from above one and two-thirds times longer than broad through pronotum, slightly impressed in meso-epinotal region. Petiolar node in profile thick and blunt at apex, anterior margin distinctly convex, posterior margin plane, truncate dorsally. Gaster elongate-ovate. Legs moderately long and slender.

Shining, finely punctate. Pilosity of an abundant reclinate pubescence which is somewhat scanty on the thorax, and long, upright hairs most numerous on thorax and gaster. Brownish yellow, mandibular teeth infuscated.

*Cotypes*.—Several workers (No. 314) which I took August 23, 1935, in virgin greenheart forest (*Ocotea Rodioei* (Schomb)) fully 4 miles north northwest of the Forest Settlement, Mazaruni River, British Guiana. This species is close to *R. göldii* but has a slightly longer head and a more distinct meso-epinotal impression. It may possibly be the worker caste of *R. borgmeieri* which is known only by the male caste.

*Biology*.—In a small collection of leaves and humus taken from the base of a large greenheart tree and brought back to camp, these ants were later found. In the collection were coccids which had probably been tended by these ants on the roots of herbs and trees just under the surface in pure gray sand. At the time of making the collection a single worker *Rhizomyrma* was seen here beneath a greenheart fruit which I had just overturned but it escaped. Also found in the collection was a new fungus-growing ant, *Myrmicocrypta unidentata* Weber 1937. According to the forester, Mr. T. A. W. Davis, whom I accompanied on this day, this greenheart forest may be considered a climax type. From then on, however, the composition of this locality will be changed since the Indians were just starting to cut out the smaller trees to give the younger greenhearts a better chance to develop.

***Acropyga (Rhizomyrma) paludis*, sp. nov.**

## Figure 15

*Worker*.—Length 2.4–2.8 mm., average of 9 workers 2.5 mm. (of thorax 0.6 mm.). Head in front view, excluding mandibles, 1.1 times longer than broad, occipital margin distinctly impressed medially, sides and anterior clypeal margin convex; eyes comparatively large (0.06 mm. in diameter), situated a distance about twice their diameters from the mandibular insertions; antennae 11-segmented, scapes failing to reach occipital angles by a distance less than their distal diameters, first funicular segment about equal to the next three taken together; mandibles stout, 4-toothed, the teeth stout and one worker with a denticle between the second and the third tooth of the right mandible. Thorax in side view with concave anterior pronotal margin, distinctly impressed pro-mesonotal suture, evenly convex mesonotum, broad and impressed meso-epinotal area with distinct spiracles, and convex epinotum; from above one and two-thirds times longer than broad through pronotum, meso-epinotal region slightly impressed. Petiole in side view, with convex anterior surface, blunt apex, which is emarginate above, and feebly concave posterior surface. Gaster elongate-ovate. Legs moderate.

Shining, finely punctate. Pilosity of a comparatively scanty reclinate pubescence which becomes coarser and longer posteriorly and sparse, long, upright hairs. Yellowish brown, head darker, mandibular teeth infuscated.

*Male*.—Length 2.7 mm. (of thorax 0.8 mm.). Head in front view, excluding mandibles, 1.1 times longer than broad back of eyes, occipital margin convex, anterior clypeal margin convex, eyes large (0.2 mm.), hemispherical, separated from the mandibular insertions by one-fifth the eye diameter; antennae 12-segmented, scapes exceeding occipital angles by over one-fifth their lengths, first funicular segment slightly shorter than next three taken together, terminal segment about as long as the three preceding taken together; mandibles stout, 3-toothed, the apical tooth large and acute, a distinct diastema between the apical and the second tooth, second and third teeth broad, blunt. Epinotum in side view with basal and declivous surfaces joined in a rounded angle. Petiole in side view cuneate with a rounded apex which from above is slightly emarginate, posterior surface feebly concave. Wings hyaline, iridescent, with pale brown veins.

Shining, finely punctate. Pilosity of a rather sparse reclinate pubescence and a few long, upright hairs. Head and antennae brown, rest of body pale yellowish brown.

*Cotypes*.—Workers and a male of one colony (No. 308) with coccids which I took August 21, 1935, in swamp rain forest a mile back of the Forest Settlement, Mazaruni River, British Guiana. This is in the type locality of *R. borgmeieri* but comparing with the original description of the latter the present species in the male caste differs particularly in having much longer antennal scapes, first funicular and terminal segments; a marked declivity to the epinotum and a feebly emarginate apex to the petiolar node. Comparing with my *Macuto*,

Venezuela, males of *ruigersi* the present species has a longer head, which is convex instead of concave on the occipital margin medially, and is much darker. A direct comparison of the male with a *dubitata* cotype showed distinct differences. The worker is near *göldii* and *decedens* but has larger eyes and shorter scapes than the former and with longer head and shorter scapes than the latter.

*Biology*.—This species was taken in true swamp rain forest miles from any cultivated coffee or cacao in what may well be the original habitat of the neotropical members of the subgenus, the vast Guianan forest between the Orinoco and Amazon Rivers. The colony nested in the hummock of decayed wood (of corkwood, *Pterocarpus officinalis*) and humus at the base of a small tree in a locality with many buttressed trees and stilt palms. Roots of lianas and aroids extended into the hummock and upon these the ants were pasturing coccids. During midday patches of sunlight would fall upon the hummock. During most of the year this hummock would be surrounded by water. On this day, at the onset of the dry season, it was surrounded by muck and some water so as to be in effect an island. The ants were highly photophobic. Coccids and ant brood occurred in the same cavities, many of which were of carton from termites which were still working the hummock. The ants carried away the coccids by grasping them with their mandibles on the dorsal surface of the "carapace" with head end forward, the whole coccid being carried between the ant legs. Their own larvae were carried in a similar manner except that they were not particular about which end or side of the larva was uppermost.

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## NOMENCLATORIAL NOTES ON CICADELLIDAE

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The following new names are proposed:

**Macropsis breakeiana** n. n. for *M. breakeyi* Knull (Ann. Ent. Soc. Amer., 33 (2) : 371, 1940), not *M. breakeyi* Merino, (Phil. J. Sci., 61 (3), Nov. 1936.)

**Erythroneura perplexa** n. n. for *E. ordinaria* Knull and Auten (Ann. Ent. Soc. Amer., 31 (4) : 651, 1938), not *E. ordinaria* Ribaut (Faune de France 31, Homoptères Auchénorhynques 1, p. 47, 1937).

**Erythroneura tithide** var. **nudista** n. n. for *E. tithide* var. *nudata* Ribaut (*Ibid*, p. 61), not *E. nudata* McAtee (Trans. Amer. Ent. Soc., 46 : 316-317, Aug. 26, 1920).

A CHECK LIST OF THE CULICIDAE OF THE AUSTRALIAN REGION,  
by FRANK H. TAYLOR. Publication No. 1, 24 pp., 1 map, 1934.

DENGUE. PART I. MEDICAL, by GEORGE F. LUMLEY. PART II. ENTOMOLOGICAL, by FRANK H. TAYLOR. Publication No. 3, 171 pp., 28 figs., 1943.

MOSQUITO INTERMEDIARY HOSTS OF DISEASES IN AUSTRALIA AND NEW GUINEA, by FRANK H. TAYLOR. Publication No. 4, 154 pp., 75 figs., 1943.

Service Publications (School of Public Health and Tropical Medicine), Department of Health, Commonwealth of Australia. Printed by AUSTRALASIAN MEDICAL PUBLISHING COMPANY, LTD., Seamer St., Glebe, New South Wales. Paper bound, 6 x 9½ inches.

Publication No. 1 is a list of 220 species of the three subfamilies Dixinae, Chaoborinae, and Culicinae known to occur in the zoogeographical area called the Australian Region. It is based upon extensive studies for many years by Mr. Taylor. Pertinent references are given for each species.

Publication No. 3 is based mainly upon published literature. It should be of particular interest right now to medical and sanitary officers who see to the health of military personnel in those parts of the world where dengue occurs.

Publication No. 4 lists and describes the various species of mosquitoes in Australia and New Guinea known to be associated with the transmission of disease, and gives practical methods of control.

Publication No. 2 in this series, which this reviewer has not seen, deals with plumbism and chronic nephritis in young people in Queensland, and methods for the estimation of lead in biological materials.—CARL E. VENARD.



# THE ENTOMOLOGICAL SOCIETY OF AMERICA

## PROCEEDINGS OF THE THIRTY-EIGHTH ANNUAL MEETING

Columbus, Ohio, December 7-9, 1943

The Entomological Society of America held its Thirty-eighth Annual Meeting on Tuesday, Wednesday, and Thursday, December 7-9, 1943. An interval of two years had elapsed since the preceding annual meeting due to the cancellation of the Thirty-seventh Annual Meeting (cf. *Annals*, 35: 114). The program was arranged jointly by the Entomological Society of America and the American Association of Economic Entomologists, which held its annual meeting at the same time and place. The general theme of the program was "Entomology and the War." Approximately half of the program centered on the subtopic "Medical Entomology in Wartime" and the other half on "Agricultural Entomology in Wartime." Personnel of the United States Army, the United States Navy, the United States Public Health Service and the Royal Canadian Army Medical Corps took a leading part in the program and discussed the importance of medical entomology in maintaining the health of the members of the armed services.

The single program for both societies was arranged by a joint committee representing the Entomological Society of America and the American Association of Economic Entomologists. The subject matter and the conditions under which the meetings were held necessitated a program of selected topics with invited speakers for each topic. This type of program was therefore substituted (for the Thirty-eighth Annual Meeting only) for the usual procedure of members presenting papers reporting on their own research.

The Annual Public Address and the Entomologists' Dinner were omitted in order to devote all the available time to the topics of the program.

The attendance was far above expectations in view of restrictions on travel and the early December dates, approximately three hundred persons being present.

The program presented at the three-day meeting follows:

### Opening Session, Tuesday Morning, December 7

#### JOINT SESSION WITH AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

In the absence of President Charles P. Alexander, the members of both Entomological Societies were called to order at 10:30 A. M. by Secretary-Treasurer Clarence E. Mickel in the Hall of Mirrors, Deshler-Wallick Hotel. Secretary Mickel announced the appointment of the following committees:

*Nominating Committee*—H. B. Hungerford, Chairman; C. T. Brues, William A. Riley.

*Resolutions Committee*—C. L. Metcalf, Chairman; David G. Hall, Josef N. Knull.

*Auditing Committee*—R. C. Osburn, Chairman; H. O. Deay, A. G. Ruggles.

Secretary Mickel introduced Dr. P. N. Annand, President of the American Association of Economic Entomologists, who addressed the joint session of the two Societies on "The War and the Future of Entomology."

### **Second Session, Tuesday Afternoon, December 7**

#### **JOINT SESSION WITH AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS**

The session was called to order at 1:00 P. M. by Secretary Clarence E. Mickel. The following program was presented:

##### **MEDICAL ENTOMOLOGY IN WARTIME**

F. C. BISHOPP, Bureau of Entomology and Plant Quarantine,  
*Discussion Leader*

Relation of Insects to the Health of Military Personnel.

MAJ. O. R. MCCOY, Office of the Surgeon General, War Department

Entomologists and the Sanitary Corps.

COL. W. A. HARDENBURGH, Office of Sanitary Engineers, War Department.

Read by MAJOR ALDEN E. STILSON, Sn. C., Assistant Chief, Medical Branch,  
5th Service Command, Ft. Hayes, Ohio.

Insect Control at Army Training Camps in the United States.

MAJ. STANLEY J. CARPENTER, Army Sanitary Corps.

The Malaria Control in War Areas Program of the United States Public Health Service.

S. B. FREEBORN, Senior Surgeon (R), United States Public Health Service,  
Atlanta, Georgia.

Entomological Services on the Program for Malaria Control in War Areas of the United States Public Health Service.

G. H. BRADLEY, Senior Entomologist (R), United States Public Health Service, Atlanta, Georgia.

Problems of Medical Entomology of Military Importance in Canada.

MAJ. R. H. OZBURN, Royal Canadian Army Medical Corps.

Mosquito Problems in the American Tropics.

MR. W. H. W. KOMP, United States Public Health Service.

### **Third Session, Wednesday Morning, December 8**

#### **JOINT SESSION WITH AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS**

The Session was called to order at 9:30 A. M. by Dr. C. L. Metcalf. The topic "Medical Entomology in Wartime" was continued and the following papers presented:

**Chemical Control of Insects That Affect Man's Health and Comfort.**

**Fumigation.**

RANDALL LATTA, Bureau of Entomology and Plant Quarantine. (10 min.).

**Repellents, contact insecticides and larvicides.**

E. F. KNIPLING, Bureau of Entomology and Plant Quarantine, and T. C. ALLEN, University of Wisconsin. (20 min.).

**Aerosols.**

L. D. GOODHUE, Bureau of Entomology and Plant Quarantine. (10 min.).

**Fourth Session, Wednesday Afternoon, December 8**

**JOINT SESSION WITH AMERICAN ASSOCIATION OF  
ECONOMIC ENTOMOLOGISTS**

The Session was called to order at 1:00 P. M. by Dr. P. N. Annand, President of the American Association of Economic Entomologists, and the following papers were presented:

**AGRICULTURAL ENTOMOLOGY IN WARTIME**

J. J. DAVIS, Purdue University, *Discussion Leader*

**The Insecticide Situation.**

L. S. HITCHNER, Executive Secretary, Agricultural Insecticide and Fungicide Association. (15 min.).

**The Distribution of Allocated Insecticides.**

C. C. HAMILTON, War Food Administration. (10 min.).

**Insect Surveys and the Distribution of Insecticides.**

S. A. ROHWER, Bureau of Entomology and Plant Quarantine. (10 min.).

**The Effect of Shortages of Rotenone and Pyrethrum on Crop Protection and Production.**

C. E. PALM, Cornell University. (10 min.).

**Substitute Agricultural Crop Insecticides.**

N. F. HOWARD, Bureau of Entomology and Plant Quarantine, and T. ROY HANSBERRY, Cornell University. (20 min.).

**Farm Stock Insecticides.**

W. E. DOVE, Bureau of Entomology and Plant Quarantine, and J. MUNRO, North Dakota Agricultural Experiment Station. (20 min.).

**Fifth Session, Thursday Morning, December 9**

**JOINT SESSION WITH AMERICAN ASSOCIATION OF  
ECONOMIC ENTOMOLOGISTS**

The Session was called\*to order at 9:30 A. M. by Dr. P. N. Annand. The topic "Agricultural Entomology in Wartime" was continued and the following papers were presented:

**New Agricultural Crop Insecticides.**

H. L. HALLER and E. R. MCGOVAN, Bureau of Entomology and Plant Quarantine. (20 min.).

**Protection of Dried Packaged Foodstuffs for Military Usages from Insect Damage.**

E. O. ESSIG, University of California, and B. N. SMALLMAN, Grain Research Laboratory, Winnipeg, Canada. (30 min.).

**Protection of Stored and Dried Processed Foods and Seed Supplies from Insect Damage.**

R. T. COTTON, Bureau of Entomology and Plant Quarantine. (30 min.).

**Insect Problems of Seed Production.**

L. G. SMITH, Washington State College, and JOHN H. HUGHES, University of Minnesota. (20 min.).

**Sixth Session, Thursday Afternoon, December 9**

**JOINT SESSION WITH AMERICAN ASSOCIATION OF  
ECONOMIC ENTOMOLOGISTS**

The Session was called to order at 1:00 P. M. by Dr. P. N. Annand. The topic "Agricultural Entomology in Wartime" was continued and the following papers were presented:

**Bees and Seed Production.**

J. I. HAMBLETON, Bureau of Entomology and Plant Quarantine. (15 min.).

**Pest Control Industry and the War.**

WM. O. BUETTNER, Secretary, National Pest Control Association. (15 min.).

**Entomological Problems of the Victory Gardener.**

T. H. PARKS, Ohio State University. (15 min.).

**The Influence of the War on Plant Quarantines.**

E. R. SASSCER, Bureau of Entomology and Plant Quarantine. (15 min.).

**Extension Entomology Activities and Food and Fiber Production Programs.**

M. P. JONES, Extension Entomologist, War Food Administration. (15 min.).

**The Manpower Problem in Entomology.**

ERNEST N. CORY, State Entomologist, University of Maryland. (10 min.).

The following is a report of the Annual Business Meeting which was held Wednesday evening, December 8, in the Deshler-Wallick Hotel. In the absence of President Charles P. Alexander, the Presiding Officer was Dr. Clarence H. Kennedy, Managing Editor of the *Annals*.

### REPORT OF THE SECRETARY

During the year 1943, the following having been duly nominated and recommended, were elected members of the Society by mail ballot of the Executive Committee:

RALPH C. BARNES, P. O. Box 210, Jacksonville, Florida.

CAPTAIN LEWIS BERNER, A.P.O. 625, c/o Postmaster, Miami, Florida.

EDWARD McCALLUM CALLAN, Imperial College of Tropical Agriculture, Trinidad, B. W. I.

JOHN F. CURRY, P. O. Box 401, c/o California Department of Agriculture, San Pedro, California

HENRY S. DYBAS, Division of Insects, Field Museum of Natural History, Chicago, Illinois.

MAJOR MARSHALL HERTIG, Sn. C., Army Medical School, Washington, D. C.

ANITA HOFFMANN, Apartado 8026, Mexico, D. F., Mexico.

1ST LT. WAYNE L. HOWE, Army Medical School, Washington, D. C.

GEORGE LELAND McCALL, Department of Entomology, Dupont Experimental Station, Wilmington, Delaware.

BARTHOLOMEW A. MAINA, 10623 Church St., Chicago, Illinois.

SEATON CRAWFORD MENDALL, New York Agricultural Experiment Station, Geneva, New York.

CHARLES L. REMINGTON, Principia College, Elsah, Illinois.

With approval of the Executive Committee a contribution of \$50.00 was made to the Union of American Biological Societies to aid in publishing a pamphlet regarding the organization of graduate work in the biological sciences for distribution to Institutes and Laboratories in Latin America. Half of the total amount contributed was donated by the Second Vice-President of the Society.

The Executive Committee voted in June, 1943, its approval of the exploration of the possibility of holding an Annual Meeting in 1943.

PRESIDENT CHARLES P. ALEXANDER appointed Mr. C. F. W. MUESEBECK and Dr. R. E. SNODGRASS to represent the Society with power to act, at a meeting of entomologists held in Washington, D. C., June 29, 1943, to consider the possibilities of holding a joint meeting of the Entomological Society of America and the American Association of Economic Entomologists some time during 1943. The decision reached at this conference was to schedule such a joint meeting at Columbus, Ohio, on December 7-9, 1943.

With the approval of PRESIDENT CHARLES P. ALEXANDER, Mr. C. F. W. MUESEBECK and Mr. CURTIS P. CLAUSEN represented the Secretary on the program committee for the joint meeting at Columbus.

The Secretary attended a Conference of the Secretaries of the American Association for the Advancement of Science and affiliated societies at Chicago, Illinois, on October 2, 1943. The agenda of this conference were concerned with

plans and policies regarding the holding of meetings of the American Association for the Advancement of Science during the war period.

PRESIDENT CHARLES P. ALEXANDER reappointed the Nominating Committee of 1942 to serve for 1943, viz.: H. B. HUNGERFORD, Chairman; WILLIAM A. RILEY and C. T. BRUES.

PRESIDENT ALEXANDER appointed the following members as representatives of the Society on the Local Committee for Arrangements for the Columbus Meeting, the same persons also representing the American Association of Economic Entomologists: T. H. PARKS, Chairman; NEALE F. HOWARD and D. M. DELONG.

PRESIDENT CHARLES P. ALEXANDER appointed Dr. E. O. ESSIG as the representative of the Society to the Division of Biology and Agriculture of the National Research Council for the three year term 1943-1946.

DR. S. A. GRAHAM was continued as the Society's representative on the Committee for Coordination of Entomology with the War Effort.

The Executive Committee met at 7:30 P. M., December 7, 1943, at the Deshler-Wallick Hotel, Columbus, Ohio, the following officers being present: CLARENCE H. KENNEDY and CLARENCE E. MICKEL; one other member of the committee was present: C. F. W. MUESEBECK. The following alternates designated by the President and by the Secretary-Treasurer acting for the President, served in place of the absent members of the committee: D. J. BORROR, T. H. FRISON, WILLIAM E. HOFFMANN, S. A. GRAHAM, Z. P. METCALF and R. C. OSBURN.

The following were elected to membership in the Society:

EDWARD WILLIAM BAKER, Laboratorio Entomologico, Apartado 3, Colonia Anahuac, D. F., Mexico.

JOHN W. BALOCK, Laboratorio Entomologico, Apartado 3, Colonia Anahuac, D. F., Mexico.

LAWRENCE KREMER CUTKOMP, Zoology Laboratory, University of Pennsylvania, Philadelphia 4, Pennsylvania.

CHARLES ARTHUR DAMBACH, Dept. Zoology and Entomology, Ohio State University, Columbus 10, Ohio.

THOMAS R. DAVIDSON, Dept. Entomology, University of Alberta, Edmonton, Alberta, Canada.

CHARLES O. ESSELBAUGH, 703 W. Nevada St., Urbana, Illinois.

ROBERT A. FLOCK, P. O. Box 1297, Phoenix, Arizona.

ST. SGT. K. GOGEL, U. S. A. A. B., A. P. O. 606, c/o Postmaster, Miami, Florida.

ROBERT EDMOND GREGG, State Teachers College, Duluth, Minnesota.

CHARLES R. HUNT, Box 62A, Dryden, Washington.

JOSEPH F. T. JODKA, Comstock Hall, Cornell University, Ithaca, New York.

ESMOND BRADLEY MARTIN, 465 East 57th St., New York 22, New York.

IBRAHIM EL MINCHAOU, P. O. B. 763, Cairo, Egypt.

MARTIN H. MUMA, 4504 Guilford Road, College Park, Maryland.

WILLIAM H. NUSHAWG, 292 Sycamore St., East Aurora, New York.

LT. JOHN V. OSMUN, Medical Branch, Hdq. 2nd Service Command, Governors Island, New York 4, New York.

THADDEUS PARR, Box 156, Bexley Station, Columbus, Ohio.

ROBERT E. PFADT, Dept. Entomology, University of Wyoming, Laramie, Wyoming.

JOHN E. PORTER, 512 W. Nevada St., Urbana, Illinois.

WILLIAM FREDERICK RAPP, JR., New Jersey Agricultural Experiment Station, New Brunswick, New Jersey.

ROBERT E. RIEDER, Extension Entomologist and Plant Pathologist, Oregon Agricultural College, Corvallis, Oregon.

P. F. C. REED STEWART ROBERTS, 346 West 1st North, Logan, Utah.

ROY D. SHENEFELT, Zoology Dept., Washington State College, Pullman, Washington.

IRVING SIEGEL, 657 Crotona Park No., New York 57, New York.

ELEANOR H. SLIFER, Dept. Zoology, University of Iowa, Iowa City, Iowa.

SUE D. SPARKS, North Carolina State College, Raleigh, North Carolina.

CARL ERNEST VENARD, Dept. Zoology and Entomology, Ohio State University, Columbus 10, Ohio.

ROBERT M. YERGASON, 50 Farmington Ave., Hartford, Connecticut.

The following have resigned during the year: A. W. BAKER, E. W. BERGER, RODNEY CECIL, EDWARD H. COE, WILEY W. CRAWFORD, LYLE H. EDELBLUTE, J. A. ELSON, LYLE E. HAGMANN, ELLIS C. KENT, CHARLES G. LINCOLN, RAYMOND E. LOWRIE, H. C. MANIS, JOSEPH B. MOORE, ANN H. MORGAN, J. B. PARKER, HAL B. PARKS, H. B. PARKS, RICHARD L. POST, DWIGHT POWELL, GORDON E. SMITH, GORDON F. SMITH, HERMAN T. SPIETH, MRS. JAMES M. SPRAGUE, PETER C. TING, DOROTHYDEAN VIETS and CHARLES S. WILSON.

The following have been automatically dropped from membership either because of failure for three or more years to pay dues or because they cannot be reached: VIRGIL N. ARGO, CHARLES CURTISS, TRABER N. DOBBINS, E. MELVILLE DUPORE, RUTH H. MADDEN, WILLIAM D. SARGENT and ALFRED ZIMMERN.

The Executive Committee elected the following Fellows: SHERMAN C. BISHOP, M. W. BOESEL, DONALD J. BORROR, E. P. BREAKEY, ELIZABETH B. BRYANT, MABEL COLCORD, ARTHUR C. COLE, JR., RALPH H. DAVIDSON, DONALD G. DENNING, HENRY DIETRICH, J. E. ECKERT, GRAHAM BELL FAIRCHILD, WILLIAM J. GERHARD, NEWELL E. GOOD, J. LINSLEY GRESSITT, ASHLEY B. GURNEY, F. H. HARRIES, LYMAN S. HENDERSON, A. C. HODSON, WILLIAM R. HORSFALL, MRS. DOROTHY J. KNULL, JOSEF N. KNULL, REGINALD H. OZBURN, H. M. PARSHLEY, FRED W. POOS, A. EARL PRITCHARD, J. SPEED ROGERS, MILTON W. SANDERSON, JOHN B. SCHMITT, FLOYD F. SMITH, CHARLES S. SPOONER, E. W. STAFFORD, HARVEY L. SWEETMAN, HENRY K. TOWNES, L. D. TUTHILL and DAVID L. WRAY.

The Society has suffered the loss by death of the following eleven members and former members during the past year: E. D. BALL, M. W. BLACKMAN, R. W. DOANE, W. P. FLINT, A. H. GREER, JOHN C. HAMLIN, W. A. HOFFMAN, FRANK E. LUTZ, R. A. MUTKOWSKI, WILMON NEWELL and ARTHUR H. ROSENFELD.<sup>1</sup>

ELMER DARWIN BALL, a Charter Member and Life Member of our Society and a Fellow since 1908, was born in Athens, Vermont, September 21, 1870, and died in Pasadena, California, October 5, 1943, after long illness. His early education was acquired in the public schools of Iowa, and he received the B.S. degree in 1895 and the M.S. degree in 1898 at Iowa State College. In 1907 he was granted the Ph.D. degree by Ohio State University, where he had pursued his graduate work under Professor Herbert Osborn, with whom he prepared many joint papers in his special field, leafhoppers and related families.

After early teaching experience in the common schools of Iowa, followed by one year as Assistant Principal of Albion Seminary in 1894-95, Dr. Ball began his scientific teaching career as assistant in zoology and entomology (1895-97) at Iowa State, and continued in the same capacity at Colorado Agricultural College from 1897 to 1901. In 1902 he became Professor of Zoology and Entomology in the Utah Agricultural College, serving in this capacity until 1907. From 1918 to 1921 he was professor of Zoology and Entomology in Iowa State College, and from 1931 until his death was Professor of Zoology in the University of Arizona, though on extended leave from the latter institution since February, 1938, when he suffered a cerebral hemorrhage which left him physically incapacitated for work.

The apparent interruptions in the continuity of his teaching career resulted from calls to special scientific and administrative services as follows: from 1907 to 1916 he was Dean of the Utah Agricultural College and Director of the Experiment Station, and from 1916 to 1918 was State Entomologist of Wisconsin, where he organized the movement for eradication of American foul brood. In 1920 and 1921 he was on leave from Iowa State College as Assistant Secretary of Agriculture, under Secretaries Meredith and Wallace; and from 1921 to 1925 was Director of Scientific Work in the U. S. Department of Agriculture. Here he backed legislation raising salaries of scientific workers in the Department, enabling it to obtain and retain better research men. From 1925 to 1928 he was in charge of celery insect investigations for the Florida State Plant Board.

<sup>1</sup>Information has just been received that 1st Lt. WILLIAM ROY WEST, a member of our Society since 1941, was killed in action during the invasion of the Marshall Islands on January 31, 1944. As far as is known, Lt. WEST is the first member of our Society to give his life during this war. He was a 1st Lieutenant in the Marine Corps. He was a graduate of the University of Alabama and was a graduate assistant in the Department of Zoology and Entomology of Mississippi State College when he enlisted in the Marines in the summer of 1942.

In the fall of 1928 Dr. Ball became Dean of the College of Agriculture, and Director of the Agricultural Experiment Station of the University of Arizona, which positions he held until 1931, when he transferred to the Department of Entomology and Economic Zoology as Professor of Zoology and Entomologist of the Experiment Station.

Dr. Ball was an indefatigable investigator. He pioneered in the driving spray method of codling moth control, in methods of eradication of American foul brood, and in discovering the role of insects in the transmission of plant diseases. He first pointed out the causal relationship of leafhopper infestation of sugar beets to curly top disease of that crop; and later repeated this achievement on tip burn of potatoes—the third plant disease proved to be insect borne. He put every possible hour into collecting and taxonomic study of Jassidae, Cercopidae, Fulgoridae, and especially Membracidae.

His published contributions number about two hundred, of which over one hundred are taxonomic, more than sixty economic, and the remainder in the general field of science and administration. The latest catalog of Membracidae credits Ball with descriptions of 385 of the 1,525 known North American species of leafhoppers. In this connection he was the possessor of a rather notable scientific library; and of an outstanding private collection of the insect groups named, which was recently acquired by the National Museum.

Dr. Ball was a Fellow of the American Association for the Advancement of Science, and held membership in the following organizations: Association of Economic Entomologists (Past President); Pacific Slope Association of Economic Entomologists (Past President); Ecological Society of America; Washington Entomological Society; Washington Biological Society; Iowa Academy of Science; Utah Academy of Science (Past President); Ohio Academy of Science; California Academy of Sciences; Washington Academy of Science; and was one-time National President of the honorary society in agriculture, Gamma Sigma Delta; he was also a member of Sigma Xi and Phi Kappa Phi.

Dr. Ball was an enthusiastic teacher, helpful with counsel and financial assistance to worthy students. While he may have acquired some reputation for pugnacity in defense of his views (for he was not one to compromise), he was at all times courteous and helpful to inquiring constituents, and a most loyal friend.

In 1899 he married Mildred R. Norvell, who survives him.—CHARLES T. VORHIES.

MAULSBY W. BLACKMAN, a member of our Society since 1913 and a Fellow since 1937, died at his home in Silver Spring, Maryland, near Washington, D. C., on October 12, 1943. He was born at Lawrence, Kansas, March 26, 1876. He graduated from Kansas University in 1901, and received his Ph.D. degree at Harvard in 1905. As a teacher he was successively attached to the University of Kansas, Western Reserve University, and Syracuse University. At Syracuse he helped organize a department of entomology which placed special emphasis on forest insects, and he served as professor of entomology at this institution from 1913 to 1929. In 1929 he was appointed specialist in Scolytidae, with the rank of senior entomologist, in the Division of Forest Insect Investigations of the U. S. Bureau of Entomology, and in 1937 he joined the staff of the Division of Insect Identification of the same Bureau. Dr. Blackman's early work was chiefly on spermatogenesis in Chilopoda, but he is best known for his later studies on the biology, control, and classification of bark beetles of the family Scolytidae. Most of his papers published after 1920 deal with the classification of various species and genera of Scolytidae, chiefly of the North American fauna. His 1928 revision of the genus *Pityophthorus* is an outstanding contribution in the field of barkbeetle taxonomy. Although in poor health during recent years he retained a kindly disposition and fine sense of humor which endeared him to his associates; and he continued to work energetically to within a few days of his death.—C. F. W. MUESEBECK.

RENNIE WILBUR DOANE, a charter member of our Society and a Fellow from 1924 to 1938, was born in Des Moines, Iowa, on March 11, 1871, and died at his home in Palo Alto, California, on December 1, 1942. In 1891 he entered Stanford University with the first freshman class where he studied under President David Starr Jordan, Professor Vernon L. Kellogg, and Professor John H. Comstock and graduated with a major in Zoology and Entomology in 1896. After a short period of graduate work under Dr. Kellogg he accepted a position at Washington

State College, Pullman, Washington, in 1896 and rose to the rank of assistant professor in 1901. In this year also he accepted a position as superintendent of the Fisheries Experimental Station at Keyport, Washington, where he investigated the propagation of the Pacific Coast oyster as a possible commercial resource. He was called to teach Zoology and Entomology at Stanford University in 1905 and remained there until his retirement in 1937. When Dr. Kellogg resigned in 1920 the Department of Entomology was incorporated into the Department of Zoology and Doane became associate professor of Zoology and nominally headed up the work in Entomology until his retirement. He made notable contributions in systematic entomology by his early work and publication on the dipterous families Tipulidae and Trypetidae and by later investigations of the Coccidae and other insect pests of the cocoanut palms in the Samoan Islands.

He became an outstanding and leading economic entomologist and for many years was entomological consultant of mining and ore-smelting companies and other private enterprises in the western states. He also contributed materially to the control of mosquitoes in the San Francisco Bay Region; to the importance of disease-bearing insects in relation to public health and agriculture, and to the development of forest and agricultural entomology in general. His books on these subjects have had wide recognition and extensive usefulness and are a reminder of his ability and industry. Among these are "Insects and Disease," Holt, 1910; "Economic Zoology and Entomology," Holt (with Kellogg), 1915; and "Common Pests," Thomas, 1931. In addition, he published at least 47 other papers.

He was an outstanding and successful teacher and he had a marked influence on the development of Entomology in the West. His wife, Elanora Cooper Doane, whom he married in 1898, and who survives him, was a great aid to him and one whose counsel and help must have been a continual source of inspiration and power. My long and often intimate acquaintance with the Doanes afforded many opportunities to learn much of the fine spirit and superb character that were the sources of their power over all who had the opportunity and privilege to come under their kindly and inspiring influence.

Professor Doane was also a member of the American Association for the Advancement of Science, American Association of Economic Entomologists, Ecological Society of America, and local entomological and zoological organizations.—E. O. ESSIG.

WESLEY P. FLINT, a member of our Society since 1908 and a Fellow since 1931, was born at Southampton, New Hampshire, on May 4, 1883, and died on June 3, 1943, at Urbana, Illinois. He spent his youth on his father's truck farm.

In 1904 he was granted a certificate for the successful completion of a two-year course in agriculture at the University of New Hampshire. He was an outstanding example of a "self-made man." With only two years of college training, he entered upon practical entomological work at the age of twenty-three years and advanced continually thereafter. In 1906 he worked for the Massachusetts Gypsy Moth Commission and in 1907 for the H. L. Frost Company on forest insects. In October, 1907, he was appointed an assistant to the Illinois State Entomologist, Dr. S. A. Forbes, Director of the Illinois State Laboratory of Natural History, and remained in the service of that organization—now the Illinois State Natural History Survey—for more than 35 years. From 1917 to 1921 his title was Assistant Entomologist for Central Illinois. In 1921 he was appointed Chief Field Entomologist. In 1930 he became Consulting Entomologist for the Agricultural Experiment Station; and in 1935 his title was changed to Chief Entomologist of the Natural History Survey (four-fifths of his time) and Entomologist of the Agricultural Experiment Station (one-fifth of his time).

His interest was always in the applied phases of agricultural entomology; and, working under the able leadership of the late Professor Stephen A. Forbes for more than 20 years and with the aid of a number of very efficient assistants, he made a number of valuable contributions to the control of agricultural insects. He was co-author of a number of bulletins and circulars dealing with the spraying and dusting of fruit trees, the control of the chinch bug, the onion maggot, stored grain insects, the European corn borer, and the status and control of many other economic farm pests in Illinois. Over the vigorous protests of a number of agriculturists, he predicted that the farmers of the middle west must learn to live with the European corn borer and this prediction is now being vindicated. He was



co-author of three books on entomology: "Destructive and Useful Insects," "The Fundamentals of Insect Life," and "Insects: Man's Chief Competitors."

He was especially efficient as an extension entomologist, bringing to the farmers and fruit growers of Illinois, in non-technical language they could fully understand, much valuable advice and help in the constant fight against the insects—an important contribution to the success of Illinois agriculture. By his extensive contacts and very practical advice, he won the gratitude and respect of thousands of people engaged in agricultural work.

He was a Fellow of the American Association for the Advancement of Science and held a number of important positions in the American Association of Economic Entomologists, of which he was Vice-president in 1927 and President in 1932. In 1932 he was Chairman of the Committee on Entomological Exhibits for the Chicago Century of Progress Exposition. In 1942 he served as Chairman of the Board of Trustees of the Crop Protection Institute. He was also a member of the Committee on Crop Protection of the National Research Council.

On January 21, 1911, he married Miss Florence Bell Wraight, who survives him.—C. L. METCALF.

ALBERT H. GREER, a member of our Society since 1924, was born near Brookhaven, Mississippi, January 8, 1891, and died at Calexico, California, July 31, 1943. He was graduated from Mississippi State College in 1917 and was commissioned a first lieutenant in the Army the same year. He served on the Mexican border during the war. For a while he was employed on pink bollworm eradication by the Federal Horticultural Board, then rendered valuable service for many years at El Paso, Texas, in Mexican border inspection for the Bureau of Entomology and Plant Quarantine. He moved to Calexico, California, in 1940. He was keenly interested in the present war and offered his services. Failing to get in the Army because of ill health he became the commanding officer of the Home Guard of Calexico. He was also a member of the American Association of Economic Entomologists. He was a good student, a hard worker, a sincere friend and loyal classmate, and a faithful supporter of his profession. His wife, Maria L. Greer, seven brothers and one sister survive him.—CLAY LYLE.

JOHN CALHOUN HAMLIN, a member of our Society since 1916, was born in Anderson, South Carolina, on September 25, 1896, and died at Starkville, Mississippi, on June 8, 1943, after a brief illness. He graduated from Clemson Agricultural College in 1916 with the degree of Bachelor of Science. Immediately after graduation he was employed by the Federal Bureau of Plant Industry as a citrus canker inspector during the summer. Doctor Hamlin was assistant in zoology and entomology at Ohio State University during 1917, from which institution he obtained the degrees of Master of Science in 1918 and Doctor of Philosophy in 1928. His Doctor's thesis was "An Inquiry into the Stability and Restriction of Feeding Habits of Certain Cactus Insects," which was published in the ANNALS. In 1918-1919 he served as plant quarantine inspector for the Federal Horticultural Board, and in this position became acquainted with the late Dr. W. D. Hunter, to whom Dr. Hamlin gave credit for instilling in him a respect for hard work and a devotion to high ideals. From 1920 to 1923 he was entomologist and biologist for the Australian Commonwealth Prickly-Pear Board which was engaged in the investigation of insects attacking the Cactaceae in the United States and Mexico and their possible introduction into Australia for the biological control of the prickly-pear cacti, *Opuntia* sp., which had been introduced into Australia and had spread over about 60 million acres in Queensland and New South Wales. Dr. Hamlin was officer in charge of these investigations during 1923 and 1924 and through his efforts was successful in importing and establishing in Australia several species of insects which fed upon the prickly-pear cacti.

Following this assignment in 1924 he was appointed Associate Entomologist in the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, to investigate insects affecting dried fruit, with headquarters at Fresno, California. With the expansion of the alfalfa weevil investigations in Utah he was transferred in 1928 to this project and located at Salt Lake City. Upon the completion of these investigations in 1940 to which Dr. Hamlin made notable contributions, he was assigned to a study of the biology and ecology of the Mormon cricket with special reference to the phases which had a direct bearing on large scale control programs for this pest with headquarters at Winnemucca, Nevada. With the inauguration of a long time plant breeding program to develop hybrid

corns suitable for commercial production in the South by the Department of Agriculture in cooperation with the Southern State Experiment Stations, Dr. Hamlin was selected to initiate studies on the entomological phases of this corn breeding problem. These studies were undertaken late in 1942 with headquarters at State College, Mississippi. Those who have worked under his direction were stimulated and inspired by his enthusiasm and solid approach to the problem at hand and because of his sound judgment and wide experience his advice and guidance were often sought by associates working in similar fields. Those who knew him will carry memories of his cordial hospitality, his unflinching kindness, and good sense of humor. His untimely death is felt by his many associates and by it entomology has lost one of its outstanding workers. Dr. Hamlin's publications cover a wide field on both biology and chemical control of insect pests. He was a member of the American Association for the Advancement of Science and the American Association of Economic Entomologists.

He is survived by his wife, Helen Hamlin, and by two daughters of a former marriage. —J. C. DOUGLASS.

WILLIAM ALBERT HOFFMAN, a member of our Society since 1914, a Life Member since 1926, and a Fellow since 1940, was born in Long Branch, New Jersey, April 18, 1894, and died in San Juan, Puerto Rico, on April 4, 1943. He received his B.S. from Cornell University in 1917 and his Sc.D. from Johns Hopkins School of Hygiene and Public Health in 1924. The following year he was a Medical Entomologist of the Haiti Survey of the International Health Division of the Rockefeller Foundation. On the completion of this work in 1926 he was appointed to the staff of the School of Tropical Medicine at San Juan, Puerto Rico, where he was entrusted with the important work of organizing the Department of Parasitology of the then newly founded institution, with which he was so closely identified for the last seventeen years of his life.

At Johns Hopkins he was an assistant of the late Dr. F. M. Root, under whose guidance he completed his Doctor's thesis on the *Culicoides* of North and Central America and the West Indies, and with whom in 1937 he published a comprehensive revision of the North American species of *Culicoides*. He was well acquainted with the mosquitoes and had made several surveys in the Caribbean region. His interests in the whole field of systematic entomology were very broad, and many of the records of insects, particularly of Coleoptera and insects of medical or veterinary importance, in G. N. Wolcott's "*Insectae Borinquensis*"—a check list of the insects of Puerto Rico—are the result of his work as a collector.

His interests were by no means limited to entomology. His early work in Puerto Rico showed the incidence and distribution of *Wuchereria bancrofti* on the Island and included papers on *Fasciola hepatica*. His later work centered about Manson's schistosomiasis. He published a series of papers written in part with Dr. E. C. Faust and others concerning the distribution of *Schistosoma mansoni* in Puerto Rico, the local species of intermediate snail host of *Schistosoma*, details of biology and epidemiology, improvement of concentration methods in searching for ova in the feces, and refinements in the experimental means of inoculation of animals with schistosome cercariae. With Dr. W. H. Taliaferro he developed a skin test for diagnosing schistosomiasis.

Dr. Hoffman was severely crippled by infantile paralysis at the age of two and could walk only with the aid of special braces. In spite of this difficulty he made frequent field trips and would set a stiff pace for many a younger and more healthy collector. He refused, in fact resented, any offer of aid. By his determination to equal or surpass the endeavors of people more favored physically, his careful observation, and his sound reasoning he became an outstanding scientist and authority on parasitology. Psychologically, he fought an uphill battle all his life, frequently being seized by periods of depression. At such times he often found comfort in playing his beloved violin or viola.

Parasitologists and entomologists will remember him through his contributions to their fields. His more intimate associates will remember him for his ability to inspire enthusiasm in all who worked near him, for his generosity towards those who needed a helping or guiding hand, and for the humble simplicity and almost ascetic austerity of his life.—HARRY D. PRATT.

FRANK E. LUTZ, a Charter Member of our Society, a Fellow since 1917, and its President in 1927, was born at Bloomsburg, Pennsylvania, on September 15, 1879, and died in New York, N. Y., on November 27, 1943, after a lingering illness.

Into the relatively brief span of sixty-four years he crowded activities and accomplishments which would have surfeited a much longer lifetime. Broadly trained in biology and bountifully endowed with great energy and keen vision, he gained international reputation for the excellence of his research on the genetics, physiology and ecology of insects. Always a champion of insects for the large part they play in our everyday life, which is virtually unheralded, he sought to measure the good of the many against the notorious depredations of the few. Always he found the scales heavily weighted in favor of the beneficial kinds and chose to emphasize this fact. Much of his life was devoted toward a graphic presentation of these creatures to the public by means of writings and lectures. The splendid "Hall of Insect Life" in the American Museum, his "Field Book of Insects" and "A Lot of Insects" stand as monuments of his devotion to the field of popular education.

After graduating from Haverford College in 1900 with a degree of Bachelor of Arts he spent several years as student and biological researcher during which he acquired a liking for and became determined to enter the field of entomology. During these formative years he was strongly influenced by the emerging application of statistical methods to biological problems. One of the results was a year spent at University College, London, studying the biometry of Professor Karl Pearson, and other years at the University of Chicago where he continued this type of study under Professor C. B. Davenport. As a Research Investigator for the Carnegie Institution he spent five years on biological investigations at the Station for Experimental Evolution at Cold Spring Harbor, Long Island, New York. He was one of the first biologists to recognize the merits of the fruit fly *Drosophila* as an experimental animal and thus shared in the preparation of the field for epochal discoveries in genetics. Many of Dr. Lutz's papers were concerned with heredity and this subject continued to be of great interest to him throughout his life. One of his most quoted contributions (and one that he belittled for its brevity and the relative ease of preparation of the paper) is concerned with the inheritance of the manner of clasping the hands. The degree of Doctor of Philosophy was granted to Dr. Lutz in 1907 by the University of Chicago. In his thesis, which was entitled "The Variation and Correlations of Certain Taxonomic Characters of *Gryllus*," he demonstrated statistically that many of the so-called "species" of our common black crickets represented little more than geographical or morphological variants.

Soon after receiving the Doctorate, Dr. Lutz was appointed (1909) as an Assistant Curator in the department of Invertebrate Zoology of the American Museum of Natural History in New York, N. Y. For thirty-four years he was identified with the American Museum and for the last twenty-two years until his death he was the Curator of the separate department concerned with Insects and Spiders. Under his personal leadership this department grew rapidly to take its place with the three or four largest entomological repositories in the United States. Although it was one of Dr. Lutz's boasts that he had never described a "new species," he always strongly sponsored systematics and contributed in an unusually vigorous way toward the accumulation of material from which hundreds of species have been named. Many of these species bear his name. More than twenty field trips were taken to all parts of the western hemisphere for field collecting or for special studies. One of the earliest trips took him to Kaieteur Falls in the interior of British Guiana, and ten other ones found him in tropical situations in Mexico, Central America and the West Indies. Within the United States he visited virtually every state and in many of them he spent months making faunal collections or studying biological problems concerned with insects. Although he traveled many thousands of miles in such expeditions, he was always emphatic in the belief that his most interesting discoveries were made in his own back yard at Ramsey, New Jersey.

The role of Dr. Lutz in the field of popular entomology and nature study has been of national import. It was always a personal triumph for him to find that he had been instrumental in directing new devotees into the field of natural history. Sincerity in their interest in insects was the only qualification for audience and advice from him to school boy, business executive, or scientist. Thousands of students and amateurs owe a debt of gratitude to him for the "Field Book of Insects," which was prepared specifically to fill their need for an authoritative primer on insects. Never was he content to allow his numerous

technical research problems to gather dust as learned works. By means of popular articles and lectures he made his discoveries available to a large segment of the population. The first "nature trails" and "trailside museums" are products of his fertile imagination. He was frequently called in as adviser to museums, national and local parks, the various organizations for youth, etc., on problems relating to natural history. Dr. Lutz will long be remembered for his long list of papers which describe his technical research projects of which only a few can be even mentioned here. In 1923 he was awarded the Morrison Prize for a paper which included a study of "The Colors of Flowers and the Vision of Insects with Special Reference to Ultraviolet," in which he showed among other things that there is an invisible color pattern on some flowers which is apparently visible to insects. Other important studies were concerned with geographical distribution, the recording and interpretation of insect sounds, the sensory behavior of the honey bee and stingless bees, and studies on the diurnal rhythm of various insects. In the excellence of his contributions as scientist and educator we find a fitting tribute to his favorite "wonder creatures."—W. J. GERTSCH.

RICHARD ANTHONY VON MUTTKOWSKI, a member of our Society since 1915 and a Fellow since 1940, was born at Milwaukee, Wisconsin, March 4, 1887, and died at Detroit, Michigan, April 15, 1943. He took the A.B. degree at St. Lawrence College in 1904 and at St. Paul Seminary in 1904. The A.B. degree was again awarded him at the University of Wisconsin in 1913. He received the Ph.D. degree from the University of Wisconsin in 1916. He served as an Assistant in the Department of Invertebrate Zoology at the Milwaukee Public Museum from 1906 to 1912. After receiving his Doctorate Dr. Muttkowski was Instructor in Zoology at the University of Missouri in 1916-1917 and at Kansas State College in 1917-1918. In 1919 he was called to the University of Idaho, serving as Assistant Professor of Zoology and Entomology until 1922 and Associate Professor in the same subjects until 1925. Dr. Muttkowski then accepted a Professorship in Biology at the University of Detroit and was head of the Department of Biology from 1925 until his death. During the summers of 1914-1916 he was an investigator for the Wisconsin Geological and Natural History Survey, was an Instructor at the University of Wisconsin in 1916, and served as investigator for the U. S. Bureau of Fisheries during the summers of 1917 to 1925. During World War I he was in the Intelligence Division of the Signal Corps, 1918-1919, and an Instructor with the A. E. F. at the University of Beaune in 1919.

He was a member of the American Association for the Advancement of Science, the American Society of Zoologists, the American Microscopical Society, the Ecological Society of America, the Brooklyn Entomological Society, the Wisconsin Natural History Society, the Michigan Academy of Science and the Wisconsin Academy of Science, of which he was Secretary, 1909-1912, and Editor, 1910-1918.

He will long be remembered for his "Catalogue of the Odonata," 1910.

WILMON NEWELL, a member of our Society since 1907, was born at Hull, Iowa, March 4, 1878, and died at Gainesville, Florida, October 25, 1943. He received his B.S. at Iowa State College in 1897, his M.S. in 1899, and his D.Sc. from the same institution in 1920. He was Assistant Entomologist at the Iowa Agricultural Experiment Station from 1897 to 1899 and held the same position at the Ohio Agricultural Experiment Station from 1899 to 1902. During 1902-1903, he was Associate Entomologist and Apiarist at the Texas Agricultural Experiment Station. From 1903-1904 he was State Entomologist of Georgia. From 1904-1910 he was Entomologist of the State Crop Pest Commission of Louisiana. In 1910 he returned to Texas as Entomologist of the Experiment Station and State Entomologist, the position which he held until 1915 when he went to Florida as Plant Commissioner of the State Plant Board. In 1921 he became Dean of the Agricultural College and Director of the Florida Agricultural Experiment Stations and Agricultural Extension Division. He was a Fellow of the American Association for the Advancement of Science and a member of the American Association of Economic Entomologists (President in 1920). He was a charter member of the Florida Entomological Society and of the Newell Entomological Society, named after him.

Dr. Newell did pioneer research work on the control of the boll weevil in Louisiana and he was very much interested in apiary work in Texas and other

States, but he was best known for his activities in pest control and eradication. On first going to Florida, he was given charge of the campaign for the eradication of citrus canker, a very serious disease which had been introduced, presumably from Japan, a few years earlier. This he carried through to a successful conclusion. In spite of persistent and thorough search, no infested trees have been found since 1927. Upon the discovery of the Mediterranean fruit fly in Florida in 1929, he organized the fight against that pest, which ultimately resulted in its eradication 18 months later.

He married Helen Mabey, of Galesburg, Illinois, in 1907.—J. R. WATSON.

ARTHUR HINTON ROSENFELD, a member of our Society since 1914, was born at Petersburg, Virginia, July, 1886, and died October 6, 1942, at Washington, D. C. He received his B.S. and M.S. degrees at the Virginia Polytechnic Institute. In 1905 he was Assistant to the State Crop Pest Commissioner of Virginia and the same year went to Illinois as a state horticultural inspector. From 1906-1910 he served as Assistant Entomologist of the Louisiana State Crop Pest Commission working on the Argentine ant, especially with relation to sugar-cane insects. When the Tucuman Sugar-cane Experiment Station in Argentina was organized in 1910 he was appointed Entomologist at the institution and later served as Subdirector 1911-1913, and Director, 1913-1916. He also served as head of the Department of Entomology at the University of Tucuman, 1914-1916. From 1916 to 1921 he was Superintendent of Agriculture at the Ingenio Santa Ana, Tucuman, Argentina, the largest sugar Central in the Province of Tucuman. He was Special Technologist for Cane at the Puerto Rico Insular Experiment Station 1923-1926 and Consulting Technologist of the American Sugar Cane League, New Orleans, Louisiana, 1927-1932. From 1932 until his death he was Government Sugar Cane Technologist, Ministry of Agriculture, Cairo, Egypt.

His family was ordered out of Egypt during the summer of 1942 when the threat of invasion seemed imminent and while the airplane trip to the United States was uneventful, his sudden death came only a few weeks later.

He is survived by a wife and a son, Arthur, Jr.

Following the reading of these brief memorials, the members stood in silence in memory of the members who had died during the past year.

The total membership on December 31, 1943, is 934.

The following were recommended by the unanimous vote of the Executive Committee to Honorary Fellowship in the Society: WILLIAM T. DAVIS and ANGELO M. DE COSTA LIMA. These were unanimously elected by ballot of the membership at the Annual Meeting.

The following were elected by the Executive Committee to the Editorial Board of the *Annals* for the term expiring December 31, 1946: GEORGE M. KNOWLTON, ARTHUR GIBSON and T. H. HUBBELL.

The following were elected by the Executive Committee to the Thomas Say Foundation Committee for the two-year term ending December 31, 1945: A. C. KINSEY and E. O. ESSIG.

The Executive Committee reaffirmed the approval of a loan of \$2,000.00 from the Permanent Fund of the Society to the Thomas Say Foundation, to be secured by a five-year non-interest bearing note, and to be used for the publication of a fourth volume of the Foundation's Monographs.

The Executive Committee voted to contribute \$100.00 to the Royal Zoological Society of London for the support of the Zoological Record.

The Executive Committee adjourned at 11:00 P. M.

Respectfully submitted,

CLARENCE E. MICKEL, *Secretary*.

On motion the Secretary's Report was accepted and the recommendations of the Executive Committee adopted.

## REPORT OF THE TREASURER

## CURRENT FUNDS

## RECEIPTS

Balance on hand in Bank, December 21, 1942 (See Annals, Vol. 36, p. 153)...	\$2,424.93
From Annual Dues of Members to December 1, 1943..	3,218.62
From CLARENCE H. KENNEDY, Managing Editor of Annals..	900 00
From three Life Memberships—H. D. PRATT, WILLIAM ROGOFF and RICHARD H. DAGGY....	150 00
From WILLIAM T. DAVIS, Contribution to Union of American Biological Societies. . .	25 00
From sale of one membership list. . .	1.00

Total Receipts . . . . . \$6,719 55

## EXPENDITURES

Postage, including 2,000 three-cent stamped envelopes, and 1,000 one and one-half cent stamps..	\$ 86.52
Spahr and Glenn Printing Co., Columbus, Ohio; printing December, 1942, and March and June, 1943, Annals...	2,222 57
Letterheads for Secretary-Treasurer.....	7 50
Printing; preliminary announcements, statements, and meeting announcement postcards (including postage and return postage)...	61 00
Clerical Services . . . . .	51.35
Return of overpayment of dues . . . . .	1 00
Telegrams. . . . .	14 76
Checks of members returned by bank . . . . .	8.00
Exchange on checks at bank..	17.23
Contribution to Royal Zoological Society of London for Zoological Record..	100.55
Contribution to Union of American Biological Societies..	50 00
Traveling Expenses, S. A. GRAHAM, representative of the Society, to meeting of joint committee on Coordination of Entomology with the War Effort, Ann Arbor, Michigan, to College Park, Maryland, and return; E. O. ESSIG, representative of Society, to Annual Meeting of Division of Biology and Agriculture, National Research Council, Berkeley, California, to Washington, D. C., and return (in part)...	90.91
Transfer Life Membership Payments to Permanent Fund of H. D. PRATT, WILLIAM ROGOFF and RICHARD H. DAGGY . . . . .	150 00

Total Expenditures..... \$2,861.39

Balance in Checking Account, December 1, 1943.. 3,858.16

Total... \$6,719.55

## LIABILITIES

The Society owes the Publishers for the September and December, 1943, Annals, and for the printing of the programs for the 1943 Annual Meeting. Of the above cash receipts for dues, \$1,144.35 is for 1944 and other dues paid in advance.

## PERMANENT FUND

## RECEIPTS

Balance in Savings Account, December 21, 1942....	\$3,965.34
Interest on Savings Account, December 21, 1942, to December 1, 1943...	39.48
Interest on Liberty Bond 45554-D.....	1.43
From three Life Memberships.....	150.00

Total Receipts..... \$4,156.25

EXPENDITURES  
(None)

Balance in Savings Account, December 1, 1943....	\$4,156.25
One Liberty Bond 45554-D.....	50.00

Balance in Permanent Fund..... \$4,206.25

## RESOURCES

Liberty Bond 45554-D..	\$ 50.00
Balance in Savings Account . . . . .	4,156.25
Balance in Checking Account . . . . .	3,858.16

Total..... \$8,064.41

Respectfully submitted,

CLARENCE E. MICKEL, *Treasurer*.

On motion the Treasurer's Report was accepted, subject to the approval of the Auditing Committee.

## REPORT OF THE MANAGING EDITOR OF THE ANNALS

The Annals for 1943 will be a volume of about 700 pages, which means that the volume for 1944 may have to be smaller if present size involves an overdraft on 1944.

The Annals has been aided by a gift of \$500.00 from a friend and member of the Society, DR. WILLIAM PROCTER, whose name I may now disclose, and to whom for the Society the present Editor wishes to convey thanks. The grant has been a help in time of real need. The gift of a like amount noted in the report for 1942 was from the same source and after closing our books for 1943 we banked a similar amount from DR. PROCTER for 1944. From authors for cuts and for printing, the Annals has received another total contribution of \$498.00. For the year 1943 this is a grand total of \$998.00 received from friends over and above the amount granted the Annals from the Society's treasury. We are out the income from 76 subscriptions to Axis countries. The total loss here is over \$300.00. The Annals is a strictly business venture and lives solely on hard cash income.

We face higher printing costs in the immediate future but the Executive Committee last year turned down the suggestion that the price of the Annals to the members (annual dues) be raised to the level charged at present in other similar biological societies for their biological journals. At present the Annals at \$4.00 per year is the cheapest buy on the scientific market.

The Federal authorities have just ruled that the Annals will have to use 45 pound paper during 1944 as against 60 pound paper in the present volume. Illustrations may not appear as well but the same brand and quality of paper will be used.

Last year the new Chairman of our Department, PROFESSOR LAURENCE H. SNYDER, succeeded in convincing the Ohio State University executives that PROFESSOR DONALD J. BORROR should be given, on full University pay, one-third of his teaching time for editorial work on the Annals. This is a gift from Ohio State University to the Society of one-third of Professor Borrór's salary. It amounts, in cash, to nearly \$1,000.00 per year. Here we express our appreciation and the same for the Society. We hope that contributing authors will bear with the closer and more detailed editing that the Annals is now experiencing.

Much study has been put on format. The Managing Editor is convinced that the present format is one of the things which has attracted the present high grade and beautifully illustrated articles which have come to the Annals in recent years. An author is willing to pay for cuts and willing to put extra hours of hard work on drawing the same, thus producing finer drawings, if he feels that the journal will not discount them on thin, cheap paper or crowd them into a two-column format. The present easy format is a profitable investment in the acquisition of quality articles.

The financial summary follows:

## RECEIPTS

Non-member subscriptions. . . . .	\$ 766.71
Back numbers and reprints. . . . .	221.21
From authors for cuts.....	425.56
Gift to the Annals.....	500.00
Contributed for printing . . . . .	73.00
Bank balance from 1942 . . . . .	45.63

Total..... \$2,032.11

## EXPENDITURES

To engravers	..\$ 651 67
Office help	... 250.75
Postage.	... 80.00
Office supplies and upkeep	... 53 25
Miscellaneous....	... 52.33
Undeposited checks	... 15.67
Bank balance November 29, 1943	... 28.44
To Secretary-Treasurer.....	... 900.00
Total	\$2,032 11

Respectfully submitted,

CLARENCE H. KENNEDY, *Managing Editor*.

On motion the Report of the Managing Editor was accepted, subject to the approval of the Auditing Committee.

## REPORT OF THE TREASURER OF THE THOMAS SAY FOUNDATION

## RECEIPTS

Balance on hand, January 18, 1943...	\$372.66
1943 sales of Volume I—1 at \$2.70	.. 2 70
1943 sales of Volume II—3 at \$4.50	.. 13 50
1943 sales of Volume II—1 at \$5.00	.. 5 00
1943 sales of Volume III—3 at \$3.60	.. 10 80
1943 sales of Volume III—1 at \$4.00	.. 4 00
Interest on Savings from June 30, 1942, to December 31, 1942	.. 2 72
Total Receipts . . . . .	\$411 38

## EXPENDITURES

Postage....	\$ 1 33
Total Expenditures	\$ 1 33
Balance in Purdue State Bank, November 26, 1943	.. \$410 05
Due on 1943 sales of 4 copies of Vol. II.....	\$ 15 00

Respectfully submitted,

J. J. DAVIS, *Editor and Treasurer*.

On motion the Report of the Treasurer of the Thomas Say Foundation was accepted, subject to the approval of the Auditing Committee.

## REPORT OF THE AUDITING COMMITTEE

We, the undersigned members of the Auditing Committee, beg to report that we have carefully examined the accounts of the Treasurer of the Society, the Managing Editor of the Annals, and the Treasurer of the Thomas Say Foundation for the year 1943, and have found them to be correct and properly balanced. The accounts of the Treasurer were examined by A. G. RUGGLES, those of the Managing Editor of the Annals by R. C. OSBURN, and those of the Treasurer of the Thomas Say Foundation by H. O. DEAY.

Respectfully submitted,

H. O. DEAY,  
A. G. RUGGLES,  
RAYMOND C. OSBURN, *Chairman*.

On motion the Report of the Auditing Committee was accepted.



# REPORT OF THE REPRESENTATIVE TO THE COMMITTEE ON BIOLOGY AND AGRICULTURE OF THE NATIONAL RESEARCH COUNCIL

The meeting of the Division of Biology and Agriculture of the National Research Council convened at the Academy of Natural Sciences, Washington, D. C., on April 10, 1943. The meetings this year were unusually profitable since for the second time a considerable amount of entomological matter was presented. I think you will be interested in knowing that the agenda for the meeting contained nearly a page relating to the entomological features which were presented by your representative last year.

On the program this year was a rather extensive report of the Committee on Crop Protection which was presented by the acting chairman, J. G. LEECH. This report comprised two pages and dealt with the following matters:

1. The organization and work of the Committee.
2. A discussion of the manpower problem as affecting entomologists and plant pathologists.
3. The matter of the effect of military service on personnel.
4. A symposium on dosage experiments with insecticides and fungicides.
5. The problem of plant disease and insect surveys. It was suggested that the word "survey," being in disrepute with administrative officials and legislators, be dropped or a substitute used.
6. The desirability of pooling the efforts of entomologists and plant pathologists for their respective services, placing emphasis on crop loss *estimates* and avoiding the phrases *disease survey* and *insect survey*.
7. The need for investigating the effects on insect populations (and diseases) of the radical changes caused by war needs, in crops grown over wide areas.

DR. C. E. PALM, representative of the American Association of Economic Entomologists, and myself presented some information in connection with entomological matters, and I especially reported on the importance of the study of stored products insects in connection with new packaging materials, particularly with regard to possible loss that may be incurred in connection with the storage of foods in large warehouses over considerable periods of time.

Respectfully submitted,

E. O. ESSIG, *Representative*.

On motion this Report was approved and placed on file.

## REPORT OF THE JOINT COMMITTEE ON COORDINATION OF ENTOMOLOGY WITH THE WAR EFFORT

Most of the members of the two entomological organizations are familiar with much of the planning and duties suggested by the work of this Committee from its appointment in the Spring of 1942, through published reports and other means. Nobody, not even the members of the Committee, can evaluate the work as to extent or influence on the production program of the nation. Many of the project leaders named in earlier reports have reported specific progress to the Committee. Others, no less effective, have permitted their published recommendations to bespeak their efforts. In many cases the tasks undertaken by suggestion of the Committee so overlapped the regular duties of leaders and members of projects that there can be and should be no differentiation. Certainly all concerned have shared with all entomologists a desire to make useful all available information to those in immediate need of it and in such form as to be most helpful. That entomologists have made a sincere effort to make the work of their profession useful is not to be questioned.

The methods of transmitting needed information to those at the firing line of production have varied enormously, both as to scope of material and agencies utilized as assistance. In some instances the distribution has necessarily been localized and in other cases widespread, according to the nature of the problem itself. Some leaders have utilized established publication series, while others have discovered new agencies for disseminating entomological information. An

outstanding example of such a new agency is the cooperative effort of several dairy firms for publicizing the work of the Dairy Insect Control.

Several million copies of the very excellent brochure of pests of the dairy industry prepared by this project group have been distributed and are now available for use among dairy farmers, dairy stores and manufacturers of dairy products. In a few cases local circumstances have delayed carrying out the planned efforts so that there has been little to report. On the whole the quantity and quality of the work has been far beyond the early expectations of the Committee, and judging from the ardent endeavor so far, it may be anticipated that all project groups will continue the effort, not to accept an assignment made by others but to reach the goal set by their own determination.

*Changes in Organization.*—The lamented death of two project leaders and other circumstances make it necessary now to consider some changes in organization. The Committee has not determined the personnel of project groups, and still leaves it to the decision of chairman to make such changes as conditions may now dictate.

DR. WILMON NEWELL was chairman for the South on Citrus Insect Control. His death made a reconsideration necessary, and since control of insects attacking citrus fruits is well covered by existing agencies in the various areas, and since there seems nothing that could be added by project efforts, the Committee has dropped this project.

PROFESSOR W. P. FLINT was project leader for soy bean insects. This project is now placed under the guidance of DR. GEORGE C. DECKER.

It seems advantageous to combine the Hog Insect project with that on beef (horses) and sheep, giving it the name of Domestic Animal project, with DR. W. E. DOVE as chairman.

PROFESSOR FLINT was also chairman of the Corn Insect project and did outstanding work in organization of this effort. The project is now placed under the chairmanship of J. H. BIGGER, fortunately working in the same laboratory as did the late PROFESSOR FLINT. It seems desirable also to establish as a new project Insects Attacking Sweet Corn (especially in the East), under the chairmanship of DR. L. A. CARRUTH.

Sometime back chairmanship of the work on White Potato Insects in the East was transferred to DR. W. A. RAWLINS, but was not previously announced.

Because of the change of the work on domestic animals, the project of which DR. W. B. HERMS is chairman is now limited to Insects Affecting Man.

Since the project on Naval Stores impinges on work on other forest insects, and since there seems to be imminent a great increase in the importance of educational effort on the broader field, the project is broadened to all forest insects, and the Committee requests its member, DR. S. A. GRAHAM, to cooperate with DR. F. C. CRAIGHEAD, in a study of the changes incident to the new plan.

All new designations of project leadership remain subject to acceptance of assignments.

Quotas for 1944 production should be available shortly and all project chairmen should inform themselves of any changes in quotas as indicative of the urgency of effort in their respective fields.

*Insect Pest Survey.*—Changes in conditions incident to the war make it especially important that at all times entomologists be aware of shifts in insect populations and regarding incipient outbreaks. We cannot too vigorously emphasize the handicaps imposed at a time like this by the restriction in scope and size of the Insect Pest Survey, resulting from severe reduction in financial support of this cooperative federal and state activity. Entomologists recognize the need for economy, but believe that they are in better position to appreciate the seriousness of such a change in the survey than are persons unfamiliar with the usefulness of this undertaking. Persistent and concerted efforts should then be made to bring about a restoration of the Survey. The Committee proposes no avenue of approach, but leaves that problem to the Officers of the two organizations. It seems incumbent on all entomologists to urge that funds be restored, not only for restoration of the Survey to its former scope but for an ultimate increase in its scope.

*New and Proposed Changes in Insecticide Regulations.*—The control of insect pests involving the use of insecticides may be seriously impeded by proposed conflicting laws and regulations dealing with coloring of insecticides with specific

colors. Entomologists agree that distinctive markings may well be required, but believe that every effort should be made to prevent imposition of conflicting and impracticable regulations. Whatever regulations may ultimately be enacted, it seems especially important that they be uniform as between the states, and that they do not interfere with the distribution of insecticides in the present emergency.

Respectfully submitted,

E. N. CORY,  
S. A. GRAHAM,  
J. S. HOUSER,  
L. M. PEAIRS,  
E. F. PHILLIPS, *Chairman*.

On motion this Report was approved and placed on file.

#### REPORT OF THE JOINT COMMITTEE ON MILITARY ENTOMOLOGY

Your committee on military entomology has continued to function throughout the year. A considerable number of War-Work Training, Experience and Availability Forms have been executed by entomologists throughout the country and added to our files. These files carry the most complete information existing, in readily available form, regarding the training and experience of entomologists in this country. They have been accessible to the military authorities and have served in many instances as a basis for selecting men for entomological assignments in the military services.

The committee has maintained close contacts with the appropriate personnel officers of the Army and Navy, and the needs of those services for entomological personnel. It has aided many entomologists in civilian life to become commissioned for entomological work, or upon induction into the service to be assigned where they would have opportunity to perform work in entomological or related fields where their training and experience could be used to advantage.

Special attention has been given to the matter of bringing to attention of appropriate officers men in the ranks who by training and experience would make good commissioned officers for entomological work or would serve effectively on special entomological assignments. At present more than 40 entomologists who were serving in the ranks have been commissioned in the Sanitary Corps. The number of entomologists commissioned in the Sanitary Corps of the Army now exceeds 200 and about 100 have been commissioned in the Hospital Volunteer Corps Service of the Navy. A large number of men with entomological training or experience have been attached to Malaria Survey and Control Units of the Army and Navy for overseas antimalaria work. The number of these units now activated exceeds 200.

Your committee has been concerned largely with aiding the military in the procurement of suitably trained men for entomological assignments, and to place entomologists in the military services where their training and experience can be utilized most effectively. In its actions in this regard, however, the committee has not lost sight of the entomological manpower situation as a whole and has endeavored to aid as much as possible in preventing the disruption of teaching, research, and especially extension and control activities in entomology. Thought has been given also to post-war problems in which the services of men now in medical entomological work in the Service may be utilized in that general field at the close of the war.

Respectfully submitted,

ROBERT MATHESON,  
E. N. CORY,  
F. C. BISHOPP, *Chairman*.

On motion this Report was approved and placed on file.

#### REPORT OF THE COMMITTEE ON RESOLUTIONS

1. WHEREAS, We believe there has never been a time when it was so important for entomologists to hold national meetings as during the present critical war, as a means of perpetuating the cooperation of all of our members and as an opportunity for the exchange of important ideas,

*Therefore, Be It Resolved*, that we record our gratitude to the Committee for Local Arrangements—T. H. PARKS, Chairman, NEALE F. HOWARD and DWIGHT M. DELONG—and to the Officers of our Society for planning this meeting and for the splendid facilities secured for our meetings, including the use of tables as well as chairs for the members; and to the managers of the Deshler-Wallick Hotel for the use of their comfortable and attractive rooms and other facilities.

2. WHEREAS, the addresses given by invitation were splendid reports which demonstrated a commendable spirit of cooperation between our military men and the entomologists, and revealed a genuine appreciation of the importance of entomology in the present war effort,

*Therefore, Be It Resolved*, that this Society express its appreciation and thanks to MAJOR R. H. OZBURN of the Royal Canadian Army Medical Corps; and to the following representatives of the Sanitary Corps of the Army of the United States: COL. W. A. HARDENBURGH, Sn. C., MAJ. O. R. MCCOY, M. C., MAJ. ALDEN E. STILSON, Sn. C., MAJ. STANLEY J. CARPENTER, Sn. C., CAPT. D. G. HALL, Sn. C., LT. W. D. REED, C. E.; to LT. R. H. DAGGY, H-V (S) of the United States Navy; and to Senior Surgeon S. B. FREEBORN and Senior Entomologist G. H. BRADLEY of the United States Public Health Service, for their contributions to our program.

3. WHEREAS, during the past year the Entomological Society has suffered serious and lamentable losses due to the death of the following members: M. W. BLACKMAN, E. D. BALL, R. W. DOANE, W. P. FLINT, A. H. GREER, JOHN C. HAMLIN, W. A. HOFFMAN, FRANK E. LUTZ, R. A. MUTKOWSKI, WILMON NEWELL, and ARTHUR ROSENFELD,

*Therefore, Be It Resolved*, that we record our appreciation of the splendid services these entomologists performed during their lives and that our Secretary send to the surviving relatives of each deceased member a note of the sympathy expressed by all of us.

4. WHEREAS, the officials of Ohio State University have generously instructed the Department of Zoology and Entomology of that institution to allow PROFESSOR D. J. BORROR to devote one-third of his time to the editing of the *Annals* of our Society,

*Therefore, Be It Resolved*, that we express our appreciation of this to PROFESSOR LAURENCE H. SNYDER, Chairman of the Department of Zoology and Entomology, and to DR. ALPHEUS SMITH, Dean of the Graduate School of Ohio State University.

5. WHEREAS, it has been made known to the members of the Society that DR. WILLIAM PROCTER has made a gift to the *Annals* of the Entomological Society of America, of five hundred dollars for each of the years 1942, 1943 and 1944,

*Therefore, Be It Resolved*, that the Society extend its sincere thanks to DR. PROCTER and that the Secretary be instructed to write to DR. PROCTER expressing our appreciation.

6. WHEREAS, the greatest hazard to men on the foreign battle fronts is insect-borne diseases, which are already reported to have caused far more morbidity and fatalities among our military forces than our human enemies have,

*Therefore, Be It Resolved*, that the Entomological Society of America believes and recommends that our military authorities and other administrators should schedule Medical Entomology and Insect Control courses as a part of the training of all servicemen in the various colleges and universities where these courses are available.

7. WHEREAS, we believe that the most important function of our annual meetings is to learn about the new discoveries our various members have made and the research that they are doing so that we may all cooperate most efficiently,

*Therefore, Be It Resolved*, that at future meetings the members of the Society be invited and permitted to present papers revealing their recent discoveries, the results of their research and other observations at paper-reading sessions, instead of restricting the program to persons invited by the Program Committee, to give addresses, many of which cover only well-known and long-established facts about our science.

Respectfully submitted,

DAVID G. HALL,  
JOSEF N. KNOLL,  
C. L. METCALF, *Chairman*.

On motion the Report of the Resolutions Committee was adopted.

REPORT OF THE NOMINATING COMMITTEE

Your Committee places in nomination the following Fellows of the Entomological Society of America to fill the designated vacancies for the year 1944:

*President*—CLARENCE E. MICKEL.

*First Vice-President*—ROGER C. SMITH.

*Second Vice-President*—W. J. BROWN.

*Secretary-Treasurer*—HERBERT H. ROSS.

*Two Members of the Executive Committee to Serve until 1946*—STUART W. FROST and P. A. READIO.

*Councilors to the American Association for the Advancement of Science*—W. D. FUNKHOUSER and C. P. ALEXANDER.

Respectfully submitted,

WILLIAM A. RILEY,  
CHARLES T. BRUES,  
H. B. HUNGERFORD, *Chairman*.

On motion the Report of the Nominating Committee was accepted and the Secretary instructed to cast a ballot for the election of the persons nominated. This being done, they were duly elected.

Following the transaction of the above business, the meeting adjourned.

Respectfully submitted,

CLARENCE E. MICKEL, *Secretary*

ANNALS  
OF  
The Entomological Society of America

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THE EXTERNAL MORPHOLOGY OF THE ADULT  
TOBACCO HORNWORM

(Lepidoptera, Sphingidae)<sup>1</sup>

A. H. MADDEN,<sup>2</sup>

Orlando, Florida

A certain amount of attention has been devoted to the subject of the external morphology of the Sphingidae, but so far as is known, the complete treatment of any particular species has never appeared in the literature. In this paper a detailed description of the morphology of an adult of a typical species is presented, which may serve as an example of the structure of the entire family. The tobacco hornworm, *Protoparce sexta* (Johan), was chosen for this purpose because of its large size and availability. This species is a common pest of tobacco and tomatoes throughout the greater part of the United States, and its range extends to the West Indies and Central and South America.

The specimens, which included both sexes, were collected in Gadsden County, northwestern Florida, and the descriptions and drawings are based upon the examination of a rather large number of individuals. The usual methods, consisting of removal of the scales and boiling or soaking the various parts in potassium hydroxide were followed in preparing the specimens for morphological study.

THE HEAD AND ITS APPENDAGES

*Head capsule* (figs. 1, 4, and 6).—The head capsule is a comparatively simple structure with few sclerites. The most prominent of the anterior region is the fronto-clypeus (*fc*) which is a broad, slightly convex sclerite demarked laterally by the ocular sutures (*os*) extending from the antennal sockets ventrally to the subgenal sutures. Slightly arched frontal sutures (*fr*), between the antennal sockets, separate the fronto-clypeus from the vertex. The ventral portion of the fronto-clypeus is

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<sup>1</sup>Contribution from the Entomological Laboratory, Massachusetts State College.

<sup>2</sup>A portion of a thesis submitted in partial fulfillment of the requirements for the Degree of Master of Science. Acknowledgments are due Dr. G. C. Crampton, under whose direction the problem was undertaken, for his valuable suggestions and kindly interest in the work.

abruptly convex and forms a blunt, snout-like protuberance over the base of the mouthparts.

The subgenal sutures (*sgs*) separate the fronto-clypeus from the subgenal region, which apparently merges on either side of the head with the triangular-shaped lobes representing the rudimentary mandibles. These sutures are arched above the frontal pits (*fp*), which are clearly discernible as vertically elongated depressions marking the invaginations that form the anterior tentorial arms. Since these pits normally occur only on the epistomal or subgenal sutures, they usually provide a means of determining the point of division between the frons and the clypeus. However, the principal dilator muscles of the cibarium\* (*dlcb*, fig. 6) arise upon the area above this point, and Snodgrass (1935, p. 119) states that these muscles arise on the clypeus. Therefore, it appears that the clypeus forms a larger portion of the frontal region of the head than is indicated by the position of the frontal pits.

The compound eyes (*e*) are subglobular and prominent. Their greatest development is ventro-posteriorly and they project beyond the ventral and posterior regions of the head capsule. The inner margins are curved slightly and are approximated ventrally to some extent. Narrow ocular sclerites (*oc*) separate the eyes from the fronto-clypeus. Dorsally, these sclerites apparently terminate at the antennal sockets and ventrally they appear to merge with the subgenal regions of the head. The development of the eyes has completely obliterated the genae.

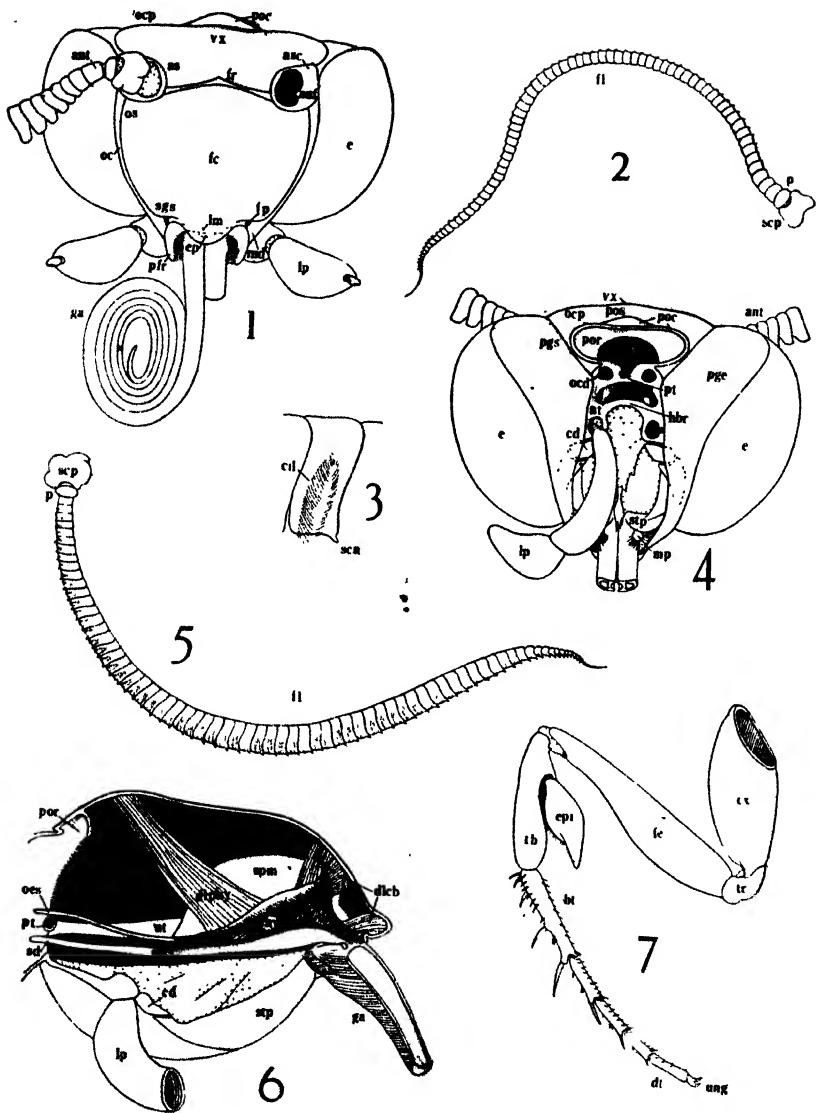
Antennal sutures (*as*), touching the inner margins of the eyes laterally, demark the narrow antennal sclerites (*asc*) which border the antennal sockets. The antennal sclerites are expanded laterally, and each of these broader areas is produced into a blunt antennifer (*anf*) which extends into the antennal socket and forms the articulatory point for the basal segment of the antenna.

The vertex (*vx*) is a large convex area at the top of the head capsule. The dorsal edge of the frontal sutures is projected upward into this area suggesting a vestigial coronal suture, which in more generalized insects divides the vertex into two parietal sclerites. Traces of the coronal suture are indicated further by a pale, lightly-sclerotized

#### EXPLANATION OF PLATE I

- FIGURE 1. Frontal view of head capsule (left antenna and palpus removed). 2. Antenna of female. 3. Lateral view of a segment of the male antenna. 4. Caudal view of the head capsule (right palpus removed). 5. Antenna of male. 6. Internal view of the left half of the head capsule. 7. Prothoracic leg.

Abbreviations: *anf*, antennifer; *ant*, antenna; *as*, antennal suture; *asc*, antennal sclerite; *at*, anterior arm of tentorium; *bt*, basitarsus; *cd*, cardo; *cil*, cilia; *cx*, coxa; *dlcb*, dilator muscle of cibarium; *dlphy*, dilator muscle of pharynx; *dt*, distitarsus; *e*, compound eye; *ep*, epipharynx; *epi*, epiphysis; *fc*, fronto-clypeus; *fe*, femur; *fl*, flagellum; *fp*, frontal pit; *fr*, frontal suture; *ga*, galea; *hbr*, hypostomal bridge; *hy*, hypopharynx; *lm*, labrum; *lp*, labial palpus; *md*, mandible; *mp*, maxillary palpus; *oc*, ocular sclerite; *ocd*, occipital condyle; *ocf*, occipital foramen; *ocp*, occiput; *oes*, oesophagus; *os*, ocular suture; *p*, pedicel; *pfr*, pilifer; *pge*, postgena; *pgs*, postgenal suture; *poc*, postoccipital sclerite; *por*, postoccipital ridge; *pt*, posterior arms of tentorium; *scn*, sense cone; *scp*, scape; *sd*, salivary duct; *sgs*, subgenal suture; *spm*, sucking pump; *stp*, stipes; *tb*, tibia; *tr*, trochanter; *ung*, unguis; *vx*, vertex.





line extending medially to the top of the head. There is no evidence of the two lateral ocelli which are located on the vertex in certain Lepidoptera.

The postoccipital sclerite (*poc*) borders the occipital foramen dorsally and laterally. It widens dorsally into a semi-circular lobe which projects outward over the occipital foramen, while ventral enlargements form the occipital condyles (*ocd*) which serve as articulatory points for the lateral cervical sclerites. Internally, the postoccipital suture forms a prominent postoccipital ridge (*por*) to which the anterior ends of the muscles moving the head are attached.

The occipital foramen (*ocf*) occupies a large portion of the posterior region of the head. The posterior arms of the tentorium (*pt*) form a bridge across the lower part, while the ventral margin is formed by the hypostomal bridge (*hbr*).

The postgenae (*pge*) occupy the spaces between the postocciput and the eyes, and extend anteriorly to the ventral surface of the head where they merge with the subgenal region. They are separated from the postocciput by the postgenal sutures (*pgs*).

The anterior arms of the tentorium (*at*) arise on the subgenal sutures near the margin of the labrum, their external manifestations being the frontal pits. They extend backward through the interior of the head capsule and connect with the posterior arms slightly mesad of the occipital condyles. The gular pits, which usually constitute the external manifestations of the posterior arms, are not apparent. However, it may be seen from the interior of the head that the posterior arms arise close to the lateral margins of the occipital condyles.

*Antennae* (figs. 2, 3, and 5).—The antennae consist of from 72 to 78 segments in both sexes. The scape (*scp*) is subcylindrical in shape and is larger than the succeeding segments, while the pedicel (*p*) is but slightly enlarged and is somewhat bulbous. The majority of the remaining segments, constituting the flagellum (*f*), are cylindrical, and in the female they are all of approximately equal size. The tip in both sexes is composed of several relatively small segments arranged in the form of a recurved hook, while each segment of the flagellum, except the first five and all but the distal segment of the tip, bears a tooth-like sense cone (*scn*) near the apex. In the male, the segments of the flagellum are broadly rounded at the dorsal margin and are rather distinctly dilated laterally so that they appear somewhat triangular in cross-section. On each of these segments there is a subapical and subbasal row of long cilia (*cil*, fig. 3). These become fused dorso-laterally to form a flattened semicircle as seen from the lateral aspect.

*Mouthparts* (figs. 1, 4, and 6).—The labrum (*lm*) consists of a narrow transverse sclerite partly concealed from the cephalic aspect by the bulbous margin of the fronto-clypeus. It is produced ventrad into a mesal and two lateral lobes. The two large and prominent lateral lobes are the pilifers (*pfr*), while the small mesal lobe represents the epipharynx (*ep*) in part. The pilifers resemble mandibles superficially but a closer examination shows that the mandibular lobes are distinct.

The large, convex, triangular mandibles (*md*) lie behind the pilifers. There is no point of articulation with the head capsule, and there are no definite sutures demarking the mandibles from the subgenae. However, vestiges of such sutures may be detected in some specimens.

The maxillae are the largest and most important of the mouth-parts. The triangular-shaped cardo (*cd*) articulates with the anterior margin of the sclerotized portion of the labium, and the subcylindrical stipes (*stp*) is curved mesally and is almost completely concealed beneath the projecting portion of the subgena. The single-segmented maxillary palpus (*mp*) is somewhat palmate in shape and is greatly reduced in size. It is borne on the anterior portion of the stipes near the point of attachment to the galea.

The galeac (*ga*), or proboscis, constitute the greater part of the maxillae. The inner surfaces are concave and the margins are held together firmly by interlocking grooves to form a long sucking tube. The basal portion of the tube opens into the sucking-pump (*spm*) which is well developed and narrows posteriorly into the oesophagus (*oes*). The floor of the pump is formed by the hypopharynx (*hy*). When not in use the proboscis is held tightly coiled beneath the head, and Schnitt (1938) states that extension is effected by the compression of the stipes which forces blood into the galeae and causes them to straighten. Muscles within the galeae cause them to recoil when the tension on the stipes is relaxed.

The structure of the labium is rather indefinite and the sclerotized portions are limited to small areas around each labial palpus, and to a short, narrow, median strip proximad of the base of the proboscis. The remainder probably is represented by the membranous portion of the ventral surface of the head. The labium is supported posteriorly by the hypostomal bridge.

The labial palpus (*lp*) consists of three segments. The basal segment is well developed and is curved forward and upward in such a way that the remaining segments are applied closely to the anterior surface of the head. The second segment is large and stout, but the third is relatively small. On the distal end there is a ventral pit which is lined with short hairs and apparently represents a sensory organ.

## THE THORAX AND ITS APPENDAGES

*Cervix* (figs. 13 and 18).—The cervix is an intersegmental region lying between the head and prothorax. It is almost entirely membranous, sclerotization being limited to a pair of V-shaped lateral cervical sclerites (*lc*). The apex of the V articulates with the anterior margin of the prothoracic episternum and is prolonged beyond the point of articulation as a short, free stem. The distal ends of the dorsal arms, or cephaligers, articulate with the occipital condyles, while the ventral arms are united by an extremely narrow bridge.

*Prothorax* (figs. 8, 13, and 18).—The prothorax is greatly reduced in size and is largely membranous.

The pronotum (*pn*) consists of three small plates partially fused together and arranged in the form of a Y. The proximal portion of the posterior plate articulates with the anterior margin of the mesothoracic prescutum, which forms a bowl-shaped depression at this point, and the anterior plates are curved around the dorsal portion of the anterior opening into the thorax. The posterior margins of these plates are broadly rounded, and their ventral margins are partially fused with the episternal sclerites. The patagia (*pg*), consisting of two

flattened lobes, are supported by the dorsal margins, and directly behind the patagia lie another pair of larger lobes which Schultz (1914) terms the parapatagia (*par*).

The episternum (*eps*<sub>1</sub>) is a convex sclerite partially fused with the ventral margin of the pronotum. All traces of the epimeron have disappeared, but the pleural suture (*ps*) is very distinct and forms a prominent internal ridge for muscle attachment. This ridge is produced ventrally on each side into two pleural arms (*pa*) which fuse with the furcal arms (*fa*). The episternum is connected with the anterior portion of the sternum by a narrow precoxale (*pr*) which passes in front of the coxal cavity. There is no trace of the postcoxale which in many insects connects the epimeron with the sternum behind the coxal cavity.

The basisternum (*bs*<sub>1</sub>) is reduced to a narrow region representing the edges of a deep, median fold. It broadens slightly into a posterior furcasternum distinguishable by the invagination giving rise to the furcae which are produced dorsally as the furcal arms.

The spinasternum (*ss*) extends almost vertically inward and then outward forming an internal strap-like process. On the exterior, it forks into two lateral arms which almost touch the anterior margin of the mesothoracic basisternum.

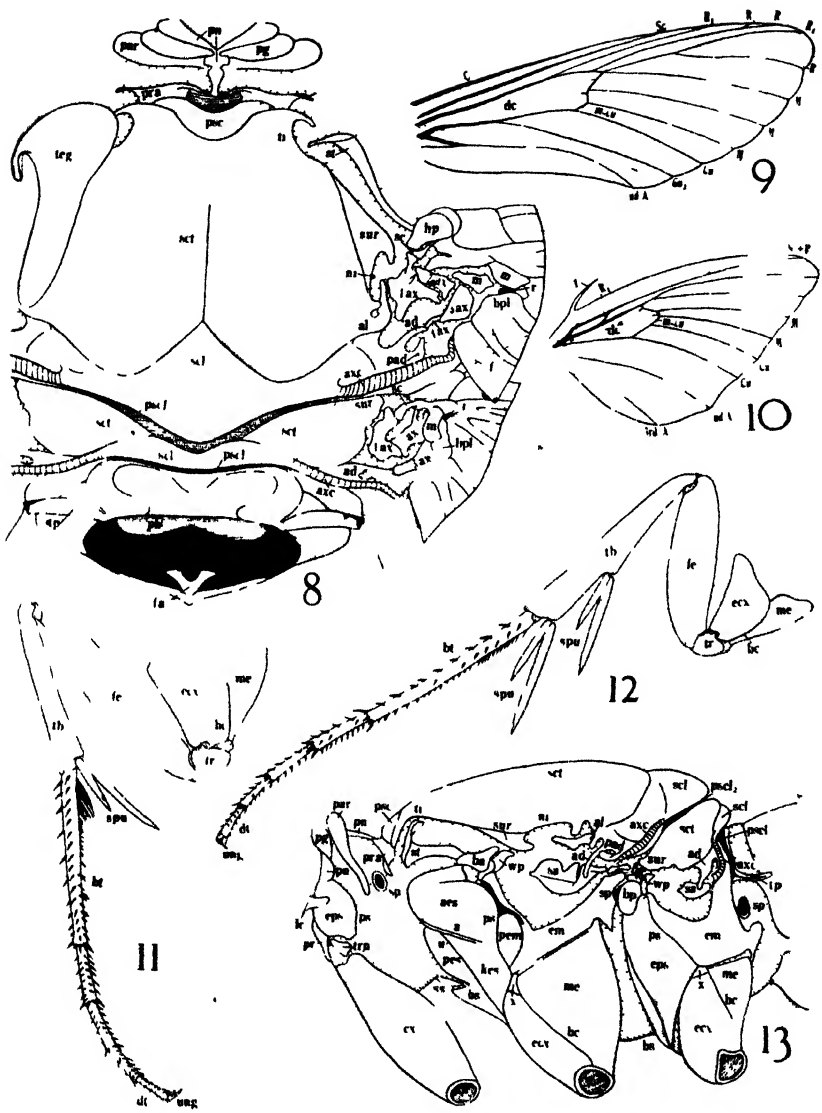
*Mesothorax* (figs. 8, 13, and 18).—The prescutum (*pse*) is a small, strongly convex sclerite lying partially in a deep semicircular cleft in the anterior margin of the scutum. It is directed ventrad and is almost invisible from the dorsal aspect. A broad, bowl-shaped depression occurs near the anterior margin, and the lateral margins are produced into two narrow prealars (*pra*) extending to the pleura.

The scutum (*scl*<sub>2</sub>) is the largest of the thoracic tergites. The anterior margin is deeply cleft, and the lateral margin is deeply notched caudad of the prealar sclerite to form the tegular incision (*ti*). Behind this point, the lateral margin is flattened into a suralare (*sur*) which

#### EXPLANATION OF PLATE II

FIGURE 8. Dorsal view of thorax (right tegula removed). 9. Fore wing. 10. Hind wing. 11. Mesothoracic leg. 12. Metathoracic leg. 13. Lateral view of thorax (tegula removed).

Abbreviations: *A*, anal vein; *a*, anepisternal suture; *ad*, adanale; *aes*, anepisternum; *al*, adnotale; *1 ax*, first axillary; *2 ax*, second axillary; *3 ax*, third axillary; *4 ax*, fourth axillary; *axc*, axillary cord; *ba*, basalar; *bc*, basicostal suture; *bp*, basalar pad; *bpl*, basoplica; *bs*, basisternum; *bt*, basitarsus; *C*, costa; *Cu*, cubitus; *cx*, coxa; *dc*, discal cell; *dt*, distitarsus; *ecx*, eucoxa; *ecx*<sub>2</sub>, mesothoracic eucoxa; *ecx*<sub>3</sub>, metathoracic eucoxa; *em*<sub>2</sub>, mesothoracic epimeron; *em*<sub>3</sub>, metathoracic epimeron; *eps*<sub>1</sub>, prothoracic episternum; *eps*<sub>2</sub>, metathoracic episternum; *f*, frenulum; *fa*, furcal arms; *fe*, femur; *hp*, humeral plate; *kes*, katapisternum; *lc*, lateral cervical sclerite; *M*, media; *m*, proximal median plate; *m'*, distal median plate; *m-cu*, medio-cubital crossvein; *me*, meron; *me*<sub>2</sub>, mesothoracic meron; *me*<sub>3</sub>, metathoracic meron; *ni*, notal incision; *pad*, postadanale; *par*, parapatagium; *pem*, preepimeron; *pes*, preepisternum; *pg*, patagium; *ph*, postphragma; *pn*, pronotum; *pr*, precoxale; *pra*, prealar; *ps*, pleural suture; *pse*, prescutum; *pscl*<sub>2</sub>, mesothoracic postscutellum; *pscl*<sub>3</sub>, metathoracic postscutellum; *R*, radius; *r*, marsupium; *Rs*, radial sector; *sa*, subalare; *Sc*, subcosta; *sc*, head of subcostal vein; *scl*<sub>2</sub>, mesothoracic scutellum; *scl*<sub>3</sub>, metathoracic scutellum; *scl*<sub>4</sub>, mesothoracic scutum; *scl*<sub>5</sub>, metathoracic scutum; *sp*, spiracle; *spu*, spur; *ss*, spinasternum; *st*, subtegula; *sur*, suralare; *tb*, tibia; *teg*, tegula; *ti*, tegular incision; *tp*, tergo-pleural groove; *tr*, trochanter; *trn*, trochantin; *u*, preepisternal suture; *ung*, unguis; *wp*, pleural wing process; *x*, epi-coxal piece.



serves as an anterior pivotal point for the wing. The median carina is quite distinct posteriorly, but becomes obliterated as it passes forward.

The subtegula (*st*) lies in the membrane laterad of the suralare. The anterior plate is directed into the tegular incision, while the longer posterior plate passes backward to the pleural wing process and serves as a prop for the anterior plate.

The tegula (*teg*) is a large, thin plate rather strongly convex anteriorly. It is supported by the subtegula to which it is attached. The anterior margin lies slightly cephalad of the tegular incision, and the posterior portion extends nearly to the base of the scutum. The antero-lateral margin is produced backward into a long, slender process which passes beneath the base of the forewing.

The postero-lateral margin of the scutum consists of a flat extension containing two lobes with a deep notch lying between them. The anterior lobe, or adanale (*ad*), is long and slender and serves as the posterior articulatory point for the wing, while the posterior lobe is shorter and stouter and represents the postadanale (*pad*). Between the suralare and the adanale, the lateral margin of the scutum is extended into a forward projecting adnotale (*al*) which functions also as an articulatory point for the wing. A deep notal incision (*ni*) lies in the edge of the scutum between the adnotale and the posterior margin of the suralare.

The scutellum (*scl*<sub>2</sub>) is a small V-shaped sclerite. The membranous axillary cords (*axc*) are continuous with the posterior marginal fold, and extend along the posterior margin of the postadanale to the anal regions of the wings.

The postscutellum (*pscl*<sub>2</sub>) is a very narrow sclerite partially concealed within a depression between the scutellum and the scutum of the metathorax. The intersegmental fold between the postscutellum and the metathoracic scutum forms a huge internal postphragma (*ph*) which is developed to such an extent that the dorsal organ and alimentary tract are forced into the ventral region of the body cavity in order to pass beneath. The postphragma affords one of the principal points of attachment for the dorso-lateral mesothoracic muscles.

The pleuron is divided by a vertical pleural suture (*ps*) into an episternum and an epimeron (*em*<sub>2</sub>). A transverse anepisternal suture (*a*) divides the episternum into a dorsal anepisternum (*aes*) and a ventral katepisternum (*kes*) which continues as a narrow precoxale and fuses with the furcasternum. The lobe-like preepisternum (*pes*) fuses ventrally with the basisternum, and is separated from the katepisternum by the preepisternal suture (*u*). A fold in the dorsal margin of the anepisternum may represent the basal portion of the basalare, but the basalare proper (*ba*) is a small, partially detached, triangular plate lying dorsad of the fold.

The epimeron is almost V-shaped, and a distinct suture cuts off the anterior portion into a subcircular region which Shepard (1930) calls the preepimeron (*pem*). The anterior margin of the preepimeron overlies the pleural suture, and its upper portion lies in a cavity parallel with the suture and extending forward into the anepisternum. The narrow antero-dorsal portion of the epimeron overlies this cavity and is produced dorsally into a pleural wing process (*wp*). The epimeron

tapers to a sharp point immediately caudad of the meron and does not form a postcoxale.

The subalare (*sa*) lies in the membrane above the epimeron. Important wing muscles are inserted upon this plate and it is invaginated mesally for this purpose. A small narrow plate, which apparently represents a second subalare, is located directly behind the subalare.

The mesothoracic spiracle (*sp*) has migrated forward and lies in the pleural membrane of the prothorax caudad of the pleural extension of the parapatagia.

The basisternum (*bs<sub>2</sub>*) is a broad, wedge-shaped sclerite which is inrolled to form a mid-ventral suture (*mv*) resembling an internal keel-shaped ridge. The furcasternum (*fs<sub>2</sub>*) is a small, triangular, deeply infolded plate, and the median invagination forms a pair of broad furcal arms which are directed slightly caudad. The ends of these arms fuse with the posterior portions of the epimera to form a brace across the caudal end of the mesothoracic cavity. There is no apparent connection between the furcal arms and the pleural ridge, which is a very unusual condition. However, the structure of the endoskeleton is so complicated by additional invaginations and infoldings that this point cannot be determined definitely.

*Metathorax* (figs. 8 and 13) — The scutum (*sc<sub>3</sub>*) consists of two lateral, lobe-like sclerites. The anterior margins are produced slightly to form the suralares (*sur*), and the flattened posterior margins are produced into two long, narrow adanales (*ad*). The scutellum (*sc<sub>3</sub>*) is a narrow transverse plate lying across the base of the scutum. The anterior margin is sinuate, and the lateral margins are produced into membranous axillary cords (*axc*) which extend to the anal region of the hind wings. The postscutellum (*pscl<sub>3</sub>*) lies immediately caudad of the scutellum, and is represented mainly by a deep invagination forming a large, internal phragma upon which a great number of muscles are attached. The membranous portion of the first abdominal tergite is attached to the posterior margin of the postscutellum.

The metapleuron is divided by a vertical pleural suture (*ps*) into an anterior episternum (*eps<sub>3</sub>*) and a posterior epimeron (*em<sub>3</sub>*). The episternum fuses ventrally with the basisternum, and on its dorsal margin there is a weakly-sclerotized, subcircular pad which Shepard (1930) calls the anterior basalare, or basalare pad (*bp*). The metathoracic spiracle (*sp*) lies directly beneath the basalare pad, and the small quadrate basalare (*ba*) is located immediately above it, while the small vertical pleural wing process (*wp*) lies caudad of the basalare. The wing process, basalare, and basalare pad represent structures for wing support and for the attachment of wing muscles.

The subalare (*sa*) lies in the membrane above a deep emargination in the dorsal margin of the epimeron. A latero-ventral extension of the postscutellum fuses with the posterior region of the epimeron to form a postalar bridge, and the upper portion of this bridge becomes deeply infolded and merges with the invagination of the postscutellum.

The basisternum (*bs<sub>3</sub>*) is reduced to a very narrow precoxale in front of the coxal cavity. The furcasternum is reduced correspondingly and the apophyses arising from it branch dorsally into an anterior and a posterior pair of furcal arms (*fa*). The anterior arms are short and

stout, while the posterior arms are much longer and fuse with the ventral margin of the epimeron to form a narrow postcoxale which is attached to the membrane of the anterior margin of the basal abdominal sternite. There is no apparent connection between the furcal arms and the pleural ridge which corresponds with the condition existing in the mesothorax.

*Legs* (figs. 7, 11, 12, and 15).—The coxa (*cx*) of the prothoracic leg is an elongated, cylindrical segment which is broadest near the base and tapers toward the distal end. It articulates proximally with the trochantin (*trn*), but the coxae of the meso- and metathoracic legs are immovably united with the pleura. The latter are divided by a basicostal suture (*bc*) into an anterior eucoxa (*ecx*) and a posterior meron (*me*) which are produced distally into trochantifers articulating freely with the condyles of the trochanter. A triangular plate at the base of the coxa of the meso- and metathoracic legs, lying between the katapisternum and the meron, is separated from the eucoxa by the basicostal suture. Snodgrass (1909) calls this plate the trochantin, but Shepherd (1930) calls it the epicoxal piece (*x*, fig. 13).

The trochanters (*tr*) of all the legs are subglobose and of about equal size. The only point of articulation is between the condyle and the trochantifer, as the distal end is immovably attached to the femur in each case.

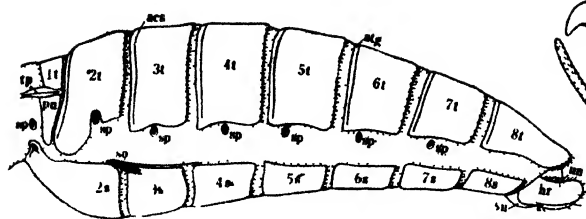
The femora (*fe*) of the pro- and mesothoracic legs are nearly twice the length of those of the metathoracic legs. The posterior margin of the femur of the prothoracic leg is broadly rounded proximally but tapers sharply toward the distal end, thus providing a space for the accommodation of the epiphysis when the femur and tibia are folded together. The femora are clothed with long hairs, but do not bear spines, spurs, or setae.

The tibia (*tb*) of the prothoracic leg is rather short and stout and the base of a prominent claw-like epiphysis (*epi*) rests in a long cavity in the posterior margin. The tibia of the mesothoracic leg is about one and one-half times the length of the prothoracic tibia. It is rather slender, but widens toward the distal end which is armed with a pair of stout spurs (*spu*). The outer spur is about twice the length of the

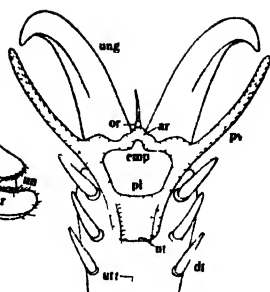
#### EXPLANATION OF PLATE III

FIGURE 14. Lateral view of abdomen of male. 15. Pretarsus. 16. Lateral view of female genitalia. 17. Lateral view of male genitalia (right harpe removed). 18. Ventral view of pro- and mesothoraces. 19. Ventral view of female genitalia.

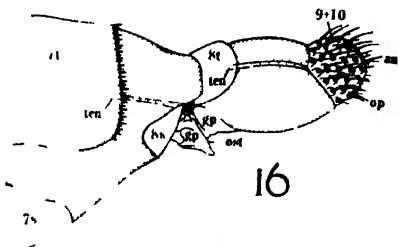
Abbreviations: *a*, anepisternal suture; *acs*, antecostal suture; *aed*, aedeagus; *aes*, anepisternum; *an*, anus; *ar*, arolium; *alg*, acrotergite; *au*, anellus; *ba*, basalar; *bs*, basisternum; *dl*, distitarsus; *ecx*, mesothoracic eucoxa; *em*, mesothoracic epimeron; *emp*, empodium; *eps*, prothoracic episternum; *fa*, furcal arms; *fs*, furcasternum; *gn*, gnathos; *gp*, genital plate; *hr*, harpe; *ix*, juxta; *kes*, katapisternum; *lc*, lateral cervical sclerite; *mes*, mesothoracic meron; *op*, oviporus; *or*, orbicula; *ost*, ostium; *pa*, pleural arm; *par*, parapatagium; *pem*, preepimeron; *pes*, preepisternum; *pg*, patagium; *pl*, planta; *pn*, pronotum; *pr*, precoxale; *pu*, pleural sclerite; *pv*, pulvillus; *rec*, rectum; *s*, sternite; *sac*, sacculus; *so*, scent organ; *sp*, spiracle; *ss*, spinasternum; *su*, saccus; *t*, tergite; *teg*, tegula; *ten*, tendon; *tg*, tergum; *tp*, tergo-pleural groove; *trn*, trochantin; *ts*, transtilla; *u*, preepisternal suture; *un*, uncus; *ung*, unguis; *ut*, unguitractor; *ult*, unguitractor tendon; *v*, vinculum; *x*, epicoxal piece.



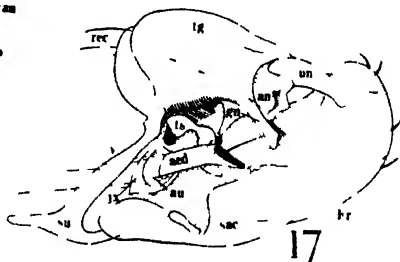
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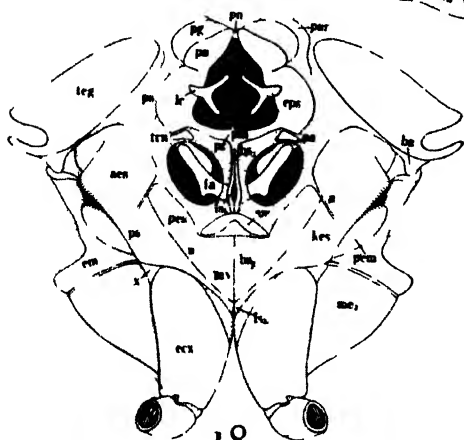
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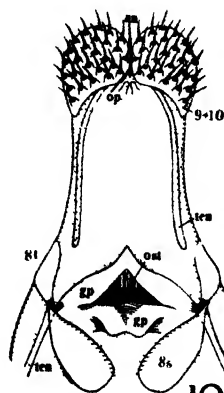
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19



inner, and is almost one-half as long as the tibia. The metathoracic tibia is about twice as long as the prothoracic tibia and is armed with two pairs of spurs. The longer spur of each pair is on the outer side.

The tarsus of each leg is composed of five segments. The basitarsus (*bt*) is the longest and it is longer in the middle and hind legs than in the fore legs. In the hind leg, it is over three times as long as any of the other segments. The segments become progressively shorter and the shortest is the distitarsus (*dt*). There are three irregular rows of stout spines on the posterior margin of the fore-tarsus, and a number of irregularly placed spines and four or five medium-sized spurs on the anterior margin of the basitarsus of the fore leg. Each tarsus of the middle and hind legs bears four rows of bristles, and in the proximal portion of the basitarsus, especially in the middle leg, the spines of the posterior row are long and bristle-like.

A pretarsus (fig. 15) is present at the tip of the distitarsus of each leg. The most prominent part is the two large, curved unguis (*ung*) which articulate with the dorsal margin of the distitarsus by means of small, hook-shaped unguifers. Two membranous pulvilli (*pr*) arise from the membrane at the base of the claws, and proximad of the bases of the claws there is a broad sclerite with a median elongation at the distal margin. The basal portion of this sclerite apparently represents the planta (*pl*), while the distal elongation is probably the empodium (*emp*). The arolium (*ar*) has been reduced to a small, membranous area above the empodium. On its dorsal surface there arises a tiny, cylindrical, sclerotized orbicula (*or*). The base of the planta is separated slightly from a narrow, ventral sclerotized unguitractor (*ut*) which is partially withdrawn into the distitarsus. The unguitractor tendon (*ult*) is attached to the proximal margin of the unguitractor and extends upward into the tibia.

*Wings* (figs. 8, 9, and 10).--The forewings are elongate-triangular in shape. The apical angles are acute, and the anal angles are distinct. The outer margins are crenulate and somewhat shorter than the inner margins, which are slightly sinuate. The hind wings are much shorter and wider and more triangular in shape than the forewings, and the apical and anal angles are broadly rounded.

The venation, which is interpreted according to the Comstock-Needham system, is shown clearly in figs. 9 and 10. In both the fore and hind wings, the basal portion of media has atrophied (hypothetical position indicated by dotted lines), and the remainder has become reduced to a three-branched condition. The first anal has atrophied in the forewing, but a vestige remains as a distinct anal furrow, which is indicated also by a dotted line. The second anal (*2nd A*) is retained, but all that remains of the third anal appears as a basal fork of the second. In the hind wing, the first anal has atrophied, but the second and third anals have been retained.

The wings are attached to the body by articular membranes which contain several axillary sclerites. The humeral plate (*hp*), at the anterior margin of the base of the forewing, articulates with the base of the costal vein. The first axillary (*1 ax*) lies caudad of the humeral plate, and the anterior arm articulates with the lateral margin of the suralare and the head of the subcosta (*sc*). The posterior portion

articulates with the adnotale, while the antero-lateral portion articulates with the second axillary (2 *ax*) which in turn articulates with the base of the radial vein and the pleural wing process. The flexor muscles of the wing are inserted on the triangular third axillary (3 *ax*), which lies caudad of the second. It articulates with the second axillary and the base of the anal vein. A very small fourth axillary (4 *ax*) articulates with the third axillary and the adanale. The proximal median plate (*m*) lies distad of the second and third axillaries, and a distal median plate (*m'*) lies slightly distad of the first. Caudad of the proximal median plate and the third axillary there is a basal knob, or basoplica (*bpl*) which fits into an anterior pocket, or marsupium (*r*) when the wings are flexed horizontally over the abdomen. Similar axillary sclerites occur in the articulatory membrane of the hind wing, with the exception of the humeral plate, distal median plate, and fourth axillary.

A frenulum (*f*) projects forward from the humeral angle of the hind wing. In the male, the frenulum is a stout, spine-like organ which is directed beneath the fore wing where the end is received in a flat, sclerotized catch, or frenulum hook, rising from the membrane between the costa and the subcosta on the ventral side of the wing. In the female, the frenulum consists of a group of about ten spine-like bristles. The tips of these bristles may be engaged in a cluster of hairs, known as the retinaculum, which occur ventrally at the base of the cubitus in the fore wing. The function of the frenulum is to coordinate the movement of the wings in flight.

## THE ABDOMEN AND GENITALIA

*Abdomen* (fig. 14).—The abdomen is elongate-conical in shape, and is composed of ten segments. However, since the last two or three are reduced and modified to form the genitalia and are retracted within the last visible segment, there are only eight apparent segments in the male and seven in the female.

The sclerotized portions of the segments consist of a tergite (*t*) and a sternite (*s*). These are separated by a membranous pleural region bearing the seven abdominal spiracles (*sp*). The segments are connected by conjunctival membranes, and each tergite and sternite normally overlaps the following tergite and sternite. A narrow acrotergite (*atg*) is demarked by a faint antecostal suture (*acs*) in all the tergites of the unmodified segments except the first. This suture forms an internal antecosta upon which the principal dorso-longitudinal muscles are attached. There is a double row of stout spines on the posterior margins of the tergites mentioned above, and there is a single row of weaker spines on the posterior margins of the corresponding sternites.

The first abdominal tergite is greatly reduced and supports a long narrow plate on its lateral margin. This plate extends forward and fuses with the edge of a fold in the posterior margin of the metathoracic postscutellum. A deep groove occurs in this plate which, according to Forbes (1923), represents the tergo-pleural groove (*tp*). A small pleural sclerite (*pu*) lies below the plate. The anterior portion of the second tergite is extended into the pleural region and probably rep-

resents the second abdominal pleurite, although it is not demarked from the tergite by a suture. None of the remaining segments have sclerotized areas in the pleural region.

The first abdominal sternite fuses with the second to form a wide plate beneath both the first and second tergites. There is a deep invagination near the upper anterior margin of this plate which gives rise to a hook-shaped process upon which certain muscles are attached.

The orifice of a scent organ (*so*) lies in the pleural membrane above the dorsal margin of the second sternite in the male, and a groove extends backward from this opening to a point above the fourth sternite. The surface of the orifice is covered with a tuft of long hairs.

*Male Genitalia* (figs. 14 and 17).—The male genitalia are composed of the highly modified ninth and tenth abdominal segments. In discussing their structure, the terminology of Eyer (1924) will be followed almost exclusively.

The tergum (*tg*) apparently represents the ninth tergite. It is strongly arched dorsally and tapers slightly toward its posterior extremity. The tergum fuses ventrally with the ninth sternite, or vinculum (*v*), which is a narrow, sclerotized band enclosing the basal portion of the genitalia and extending anteriorly to form a medio-ventral invagination, or saccus (*su*).

The paired harpes (*hr*) articulate with the posterior margin of the vinculum. They are somewhat spatulate in shape, and with the exception of certain regions are very weakly sclerotized. The inner surface of each is concave and is covered with long hairs. The dorsal region is thickened and rather heavily sclerotized, and the ventral region, or sacculus (*sac*), is heavily sclerotized and is produced into a curved inner process. The distal portion of this process is free and consists of a ventral prong separated by a deep incision from a broader upper portion with a partly serrate dorsal margin. The shape of the sacculus is constant, and it is therefore of importance in classification.

The inner dorsal angles of the harpes are connected by a transtilla (*ts*) with deeply invaginated ends which form articulatory points for the harpes. Lying within the vinculum is a cone-shaped anellus (*au*) through which the aedeagus enters the abdomen. The anellus is invaginated to form a membranous tube surrounding the aedeagus, and the ventral portion is heavily sclerotized externally forming a yoke-shaped juxta (*jx*) which supports the aedeagus. The aedeagus (*aed*) is a long sclerotized tube which serves as a protective armature and guide for the penis.

The anal armature belongs to the tenth segment and is composed of two parts. The uncus (*un*) is a single, ventrally inclined hook projecting over the anus. Superficially, it appears to be attached to the tergum because of the retraction of the tenth segment. The gnathos (*gn*) consists of paired arms arising from the tergum at the base of the uncus. The median ventral plate, which in some insects lies between the arms, is missing and the arms fuse to form a trough-like projection ventrad of the anus. The anus (*an*) marks the external opening of the rectum (*rec*) which is in the form of a membranous tube closely applied to the tergum internally.

*Female Genitalia* (figs. 16 and 19).—The eversible female genitalia are normally retracted within the seventh somite. They are still further concealed by a thick clothing of long hairs. The basal portion is made up of the eighth tergite and sternite. The eighth tergite is a simple semicylindrical plate which narrows abruptly at the point of union with the sternite. A deep invagination is formed at this point giving rise to an elongated tendon (*ten*) which extends forward into the body cavity. A similar tendon arises from an invagination in the anterior margin of the ninth segment and extends forward beneath the eighth tergite, and corresponding tendons arise on the opposite side of the genitalia. Muscles involved in the retraction of the genitalia are attached to these tendons.

The ostium (*ost*), which forms the external opening of the ductus bursae, or vagina, lies ventrad of the eighth tergite, and a part of the eighth sternite is modified to form sclerotized genital plates (*gp*) surrounding the ostium. Two partially invaginated lobes of the eighth sternite extend cephalad and are approximated mesally. A membranous tubular extension, which functions as an ovipositor, lies caudad of the eighth segment, and two sclerotized, hemispherical lobes form the terminus of this extension. These lobes are frequently referred to in the literature as the ninth segment, but Snodgrass (1933) states that they evidently represent the united ninth and tenth somites. They are covered with tubercles bearing long setae. The anus (*an*) and the opening of the oviporus (*op*) lie between these lobes. The oviporus, which is ventrad of the anus, represents the external opening of the egg duct. It forms also a posterior opening of the genitalia, a condition found only in certain Lepidoptera and in the Mecoptera. Two short, weakly sclerotized, finger-like processes lie directly below the oviporus. These processes undoubtedly function as auxillary guides in placing the egg.

## SUMMARY

1. A detailed morphological description of the adult is presented as an example of the structure of the entire family.

2. The head capsule is a relatively simple structure and the mouthparts are greatly reduced. The maxillae are the largest and most highly developed of the mouthparts.

3. The cervix is almost entirely membranous.

4. The prothorax is greatly reduced in size, while the mesothorax is greatly enlarged and its structure is very complex. The metathorax is somewhat smaller than the mesothorax and is less complicated in structure.

5. Details of the wing venation and a description of the axillary sclerites are given.

6. The abdomen is spindle-shaped and consists of ten segments, although there appear to be only eight in the male and seven in the female.

7. The male and female genitalia are composed of the modified eighth, ninth, and tenth abdominal segments. The shape of the sacculus in the male genitalia is constant and is therefore useful in classification.

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1933. Morphology of the insect abdomen. Part II. The genital ducts and the ovipositor. *Smithsn. Misc. Collect.*, 89 (8), 148 pp., 48 figs.
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STATISTICAL ADJUSTMENT OF DATA, by W. EDWARDS DEMING. Pages x and 261, 24 illustrations. Published by JOHN WILEY & SONS, INC., New York, 1943. Price \$3.50.

This work by Dr. Deming of the Bureau of the Census and Bureau of the Budget, was developed over a period of 16 years in the Government service in assisting colleagues in many branches of science and as text material for classes taught in the Graduate School of the Department of Agriculture.

The scope of the volume is indicated by the section and chapter headings as follows: Part A—Some Simple Adjustments: Chapter I, On the Meaning of Adjustment; Chapter II, Simple Illustrations of Curve Fitting. Part B—The Least Squares Solution of More Complicated Problems: Chapter III, The Propagation of Error; Chapter IV, The General Problem in Least Squares. Part C—Conditions Without Parameters: Chapter V, Geometric Conditions; Chapter VI, Systematic Computation for Geometric Conditions; Chapter VII, Adjusting Sample Frequencies to Expected Marginal Totals. Part D—Conditions Containing Parameters: Chapter VIII, Curve Fitting in More Complicated Circumstances; Chapter IX, Systematic Computation for Fitting Curves by Least Squares. Part E—Exercises and Notes: Chapter X, Exercises on Fitting Various Functions; Chapter XI, Four Examples in Curve Fitting. Appendix—Tables for Making Random Observations for Class Illustration: A, Normal Deviates Directly in Units of the Standard Error; B, Normal Distribution of the Numbers from 0000 to 9999.

The book gives rather more mathematical theory than some texts and the different topics are more generally unified under the basic principles. It is designed to supplement rather than to span other texts and seems excellent within the intended scope. Least squares and curve fitting are treated extensively and the book seems most useful as a text and reference in these fields because of the emphasis given to phases difficult to find elsewhere, such as curve fitting in the case where both the  $x$  and  $y$  values are subject to error, and other developments especially useful in conducting social and economic surveys by sampling. Some topics are not treated or are given only slight emphasis, and among these are the analysis of variance, covariance, experimental design, and plot techniques, with which many entomologists, and particularly those engaged in testing insecticides, are concerned.—F. H. HARRIES.

## A CASE OF PARENTAL CARE IN THE HETEROPTERA

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Parental care is well known in certain insects with complete metamorphosis, especially the Hymenoptera, but it is not common in insects with incomplete metamorphosis, except in the Isoptera. The Dermaptera, Embiidina and a European mole cricket care for their young and are said to be incipiently social or subsocial. Kirkaldy (1903) summarizes the subject of parental care in non-social insects especially the Rhynchota. In the lace bugs (Tingitidae) groups of nymphs are frequently found with females on the under surfaces of their respective hosts, but associations of this sort are not cases of parental care; the nymphs and the adults are together only because the females continue to lay eggs over a comparatively long period.

The writers were surprised to discover a marked case of parental care in a species of Pentatomidae, *Meadorus lateralis* (Say)<sup>1</sup>. The nymphs of all pentatomids have a tendency to assemble immediately after the eggs hatch, but in few cases do the females remain with the eggs or brood over the nymphs. Several accounts of scutellerids that care for their young occur in European literature. Mr H G Barber states (in correspondence) that while collecting in Puerto Rico in 1914 he observed a number of females of *Pachycoris fabricii* (L.) hovering over their young in much the same fashion as described by Kirkaldy for other scutellerids. As all of these accounts are meagre, the habits of *Meadorus lateralis* seem worth special mention.

**Behavior.** This insect was first noticed on July 7, 1942. At that time numerous groups of unhatched eggs and many groups of first and second instar nymphs were found upon the under surfaces of the leaves and upon the cones of black birch (*Betula lenta*). The color of the nymphs resembles the feeding scars of squirrels and other animals on the cones, which made the location of the insects difficult. The nymphs were more often found on the older trees, especially those bearing cones, and were more common in the tops of the trees. Drake (1922) refers to their habit of occupying the tree tops and remarks that they were found in felling tall trees to obtain seed. He also states that the nymphs of several instars fed in groups. As a rule, however, only individuals from a single egg mass remain together. If they are disturbed, nymphs of different instars may become mixed and the female will brood over them. The nymphs remain together during their entire development. Fifth instar nymphs were found in conspicuous clusters upon the leaves

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<sup>1</sup>This species occurs in literature under the generic names *Meadorus*, *Acanthosoma*, *Elasmucha*, *Clinocoris*, *Elasmotethus*, and *Edessa*. There is some doubt concerning the correct generic name for this species. Inasmuch as the standard texts on Hemiptera and Heteroptera use *Meadorus*, we have used this name.

and upon the cones (figs. 4 and 5). They were evident enough to be seen at a distance of twenty or thirty feet from the ground.

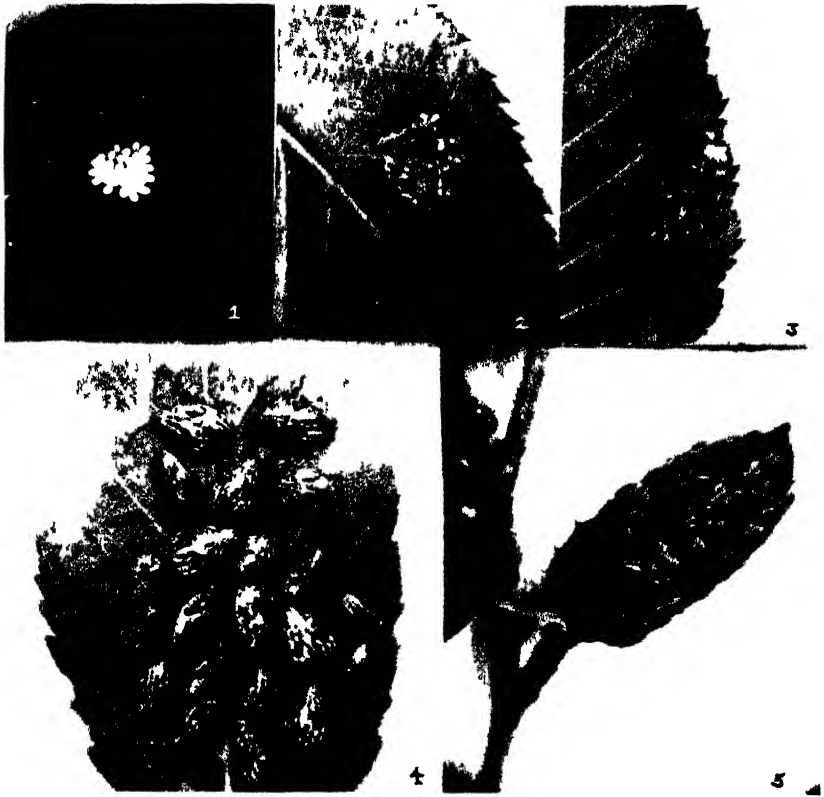
The development of this species is comparatively rapid. A batch of eggs laid in captivity on July 17 hatched on July 22. A trip to the woods on July 24 revealed that most of the first generation nymphs had reached the fourth or fifth instars. Adults from some of these nymphs emerged on July 25. Drake (1922) states that there are two generations a year. This is apparently correct for several mating pairs, and newly laid eggs were collected on July 24. On August 14 and 16 eggs, first and second instar nymphs were found in abundance.

Nymphs and adults are phytophagous, which explains why the nymphs can remain together for their complete development. The species apparently hibernates as adults.

The females were frequently found brooding over the eggs and younger nymphs (figs. 2 and 3). When they leave the nymphs is not exactly known; they were frequently seen with first, second, and third instar nymphs, but were not found with nymphs of the fourth and fifth instars. The brooding instinct is strong. The females resisted attempts to dislodge them from the leaves or from their young. As a matter of fact, some of the specimens were obtained from the tree tops by throwing sticks and stones at them. After the leaves fell to the ground, the females were invariably with their brood. If pushed from the side, the female tilts her body towards that side to protect the eggs or young. The claws of the female grip the leaf or the egg shells and she cannot be dislodged except with some difficulty. One female, deprived of her eggs, brooded over a dead male for five days. The female often vibrates her wings vigorously when disturbed. The instinct to congregate is also strong. The nymphs were observed to remain together during their entire development. Counts made on August 14th showed 16 first instar nymphs in a group, from 29 to 33 second instar nymphs grouped, and from 26 to 30 third instar nymphs grouped. Many nymphs no doubt fall prey to predacious species for they move rather slowly and the masses of nymphs are conspicuous. Predacious pentatomids have been observed attacking both adults and nymphs of *Meadorus*. Fourth and fifth instar nymphs were found in conspicuous groups usually in the tops of the trees.

*Distribution.*—*Meadorus lateralis* appears to have a northern distribution. According to Bueno (1939) it occurs from Quebec and the New England States to the Pacific coast. It does not occur south of New Jersey. In New York, Massachusetts, and Connecticut it has been reported as abundant and has been taken on yellow birch and beech. It is apparently locally common but generally scarce throughout most of its range.

The species has not been taken often in Pennsylvania. The following records are available: Inglenook, June 10, Knull; Laport, March 28 and June 3, Knull; Mt. Alto, June 3, Knull, July 27, Guyton; Sweden Valley, June 2, Knull; Chambersburg, May 28, Knull; Salisbury, Aug. 6, Guyton; Ohio Pyle, Aug. 5, Guyton; Nordmont, Aug., Pepper; South Fork Camp, Baker; Clarkes Valley, Champlain. From July 7 to August 30 the writers found the species common on black birch on Tussey Mountain near State College. The species was also found in



The birch pentatomid *Meadourus lateralis* (Say). Figure 1. Eggs on birch leaf. 2. Female brooding over first instar nymphs. 3. Female brooding over second instar nymphs; female has been pushed to the side to reveal the nymphs. 4. Cluster of fifth stage nymphs on birch leaf. 5. Two fifth instar nymphs on birch cone.



nearby localities, especially wooded areas on the hilltops. Specimens were taken at Shingletown Gap, Keith Spring, and Bear Meadows.

*Descriptions of stages.*—*Egg* (fig. 1).—The eggs are white, exceedingly shiny and somewhat elongate. They are usually laid on the upper surfaces of the leaves of birch in groups of thirty or forty.

*First Instar* (fig. 6).—The nymph, shortly after hatching, is creamy white with indistinct reddish eyes and four indistinct reddish spots on the dorsum of the abdomen. With increasing age the color gradually becomes darker; just before moulting the eyes become dark red, and the head, thorax, and legs become gray. The head and thorax are marked by a narrow central white line, and there are two diagonal white lines from the base of the head to the eyes. The underside of the body is creamy white. The labium is about three quarters the length of the body and the legs and antennae are proportionally long.

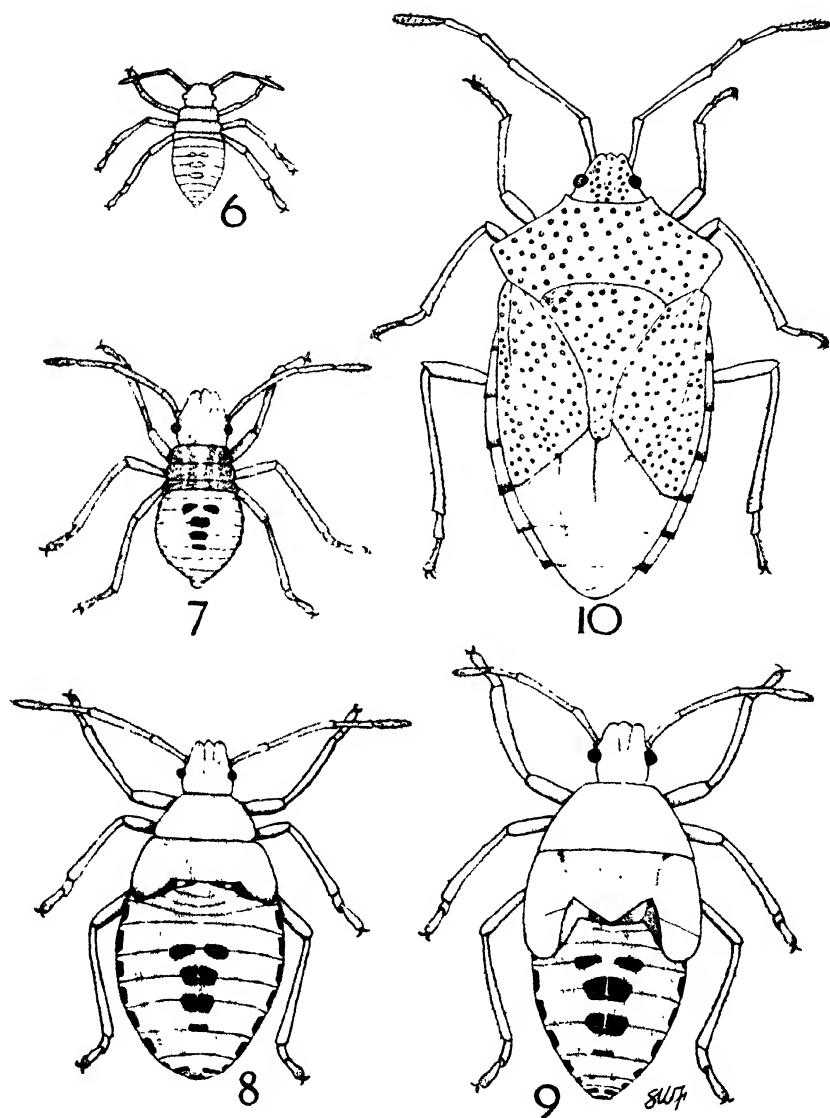
*Second Instar* (fig. 7).—The markings are more pronounced in the second instar. The dorsal surface of the head and thorax, the antennae and the legs are principally gray, although they may show a tinge of red. The thorax is marked by three narrow longitudinal white stripes which extend somewhat irregularly upon the head. The stink glands appear as five gray or brown spots on the dorsum of the abdomen. The remainder of the abdomen is red with a central white line and two white lines on each side. The edge of each abdominal segment is marked with a distinct dark spot. The under surface of the head and thorax is gray but darker along the sides. The under surface of the abdomen is cream-colored in the center and red along the sides.

*Third Instar* (fig. 8).—The wing buds begin to appear externally in the third instar. The thorax is brownish to pinkish with three longitudinal lines which are not as regular as those of the 2nd instar. The three white lines on the head are more pronounced. The abdomen is largely red. The dorsal aspect bears seven more or less distinct white longitudinal lines. The stink glands and the spots along the edge of the abdominal segments are conspicuous. The under surface of the nymph is creamy white in the middle and red along the sides. The labium is about two thirds the length of the body.

*Fourth Instar.*—The fourth instar is very similar to the third instar as far as color markings are concerned. It differs chiefly in size.

*Fifth Instar* (fig. 9).—In color the fifth instar resembles very closely the third and fourth instars. The wing pads are more conspicuous and reach nearly to the posterior edge of the third abdominal segment. The thorax is less distinctly colored than the preceding instar but the markings of the abdomen are similar. The labium is about two-thirds the length of the body. The antennae and legs are proportionally shorter.

*Adult* (fig. 10).—"Oblong-oval, subdepressed above, subconvex beneath. Above greenish yellow, rather evenly, not thickly marked with coarse reddish-brown punctures; antennae reddish-yellow, the tip of the last joint blackish; elytra with 2 vague reddish-brown or pale fuscous cross-bars; connexivum yellow, with an oblong blackish spot on each incisure; tergum reddish; under surface pale yellow, the punctures darker; legs reddish yellow. Cheeks sparsely unevenly punctate; tylus almost smooth, its front half widened and with a median groove. Pronotum with front portion unevenly punctate, the smooth



Life stages of *Meadorus lateralis* (Say) Figure 6. First instar nymph.  
7. Second instar nymph. 8 Third instar nymph. 9. Fifth instar nymph.  
10. Adult.

areas irregular and transverse; hind portion evenly and coarsely punctate. Scutellum very coarsely and sparsely punctate; elytra more finely and rather closely so. Abdomen with minute distant punctures, those of the thoracic pleura coarser. Length, 7.5–8.5 mm.; width, 4.5–5 mm." (After Blatchley, 1926.)

The Acanthosomatinae, including the genera *Meadorus* and *Elasmothethus*, are characterized by the two-segmented tarsi and a distinct ventral carina. The carina of *Meadorus lateralis* (Say) consists of two portions, a keel on the thorax terminating in a backward projecting spine, and a similar keel on the abdomen terminating in a forward projecting spine. The terminal spines of these two carinae overlap in the area between the mid and hind coxae. The tip of the thoracic carina is always to the left of the tip of the abdominal carina. When the thorax bends these terminal spines slip by one another. The thoracic carina is distinct for its entire length. It is fused along the meta- and mesothorax but the anterior end is free and projects over the prothorax, fitting into a groove in the cephalic margin of the prosternum. The abdominal carina is distinct on the anterior portion but is indistinct posteriorly, although it reaches to the genital cleft. The labrum is always held to the left of these carinae.

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# THE EXTERNAL MORPHOLOGY OF THE OBLONG-WINGED KATYDID, *AMBLYCORYPHA OBLONGIFOLIA* (DeGEER)

(Orthoptera, Tettigoniidae)<sup>1</sup>

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This study has been undertaken for the purpose of providing a detailed account of the external morphology of a phaneropterine insect of the family Tettigoniidae, order Orthoptera. Although a few isolated accounts of portions of such insects are available, no complete and comprehensive study of the morphology of an insect belonging to the subfamily Phaneropterinae has been made. Information on the external morphology of this insect should give the student of phylogeny a clearer understanding of the phylogenetic position of the group, and indicate to the taxonomist the structures that are significant in classification. It should also provide a morphological basis for future studies and observations on the singing mechanism of these insects.

The members of the subfamily Phaneropterinae are commonly known as the "false katydids," in contradistinction to the closely allied subfamily Pseudophyllinae which are designated as the "true katydids." One of the characteristics of the Phaneropterinae which distinguish them from the Pseudophyllinae is that the hind wings are longer than the tegmina, whereas in the Pseudophyllinae the hind wings are shorter than the tegmina. Although the members of the Phaneropterinae produce a definite call, their sound hardly resembles the familiar "katy did, she did, she didn't," and it should be noted that it was the song of one of the true katydids (Pseudophyllinae) which gave rise to the common name for the group.

The species *Amblycorypha oblongifolia* (DeGeer) is a typical representative of the Phaneropterinae, with a wide range. According to Blatchley (1920) the known range of this species is "from New England and Montreal west to southwestern Ontario, Michigan, Minnesota and Colorado, and south and southwest to Maryland, North Carolina,

<sup>1</sup>This study was undertaken at the suggestion of Dr. G. C. Crampton. The writer is deeply indebted to him for his valuable advice and criticism throughout the progress of this study, and for the specimens which he was kind enough to supply.

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Appreciation and thanks are due Miss Ruth Keller who was kind enough to type the original manuscript, and to Dr. A. B. Gurney, formerly of the National Museum, who determined the species under consideration as *Amblycorypha oblongifolia* (DeGeer).

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Alabama, Louisiana and Texas." Thus it might easily be made available for class study in morphology, and its size and the primitive structure of many of its parts would give the beginning student in morphology a sound basis for understanding the more specialized structures found in the members of higher Pterygotan orders.

The members of the genus *Amblycorypha* Stål are commonly known as the "round-headed katydids," and *A. oblongifolia* is specifically known as the Oblong-winged Katydid. The following description of the species is taken from Blatchley:

"Size large for the genus; form robust. General color a bright pea-green, the shrilling organ of male brownish, with a heavy green crossvein; abdomen and usually the fore and middle femora, yellowish or brownish green; hind femora often brownish-yellow. Disk of pronotum with sides distinctly divergent on basal two-thirds, subparallel with lateral carinae less distinct on apical third; humeral sinus well impressed; hind margin of lateral lobes broadly rounded. Tegmina elongate-elliptical, about 3.3 times as long as wide. Wings in repose surpassing tegmina six or more mm. Hind femora very slender, usually scarcely reaching tip of tegmina, female, distinctly shorter, male, their inner lower carina armed with six to twelve rather strong teeth.

"Length of body, ♂, 21-23, of ♀, 22-25, of pronotum, ♂, 6-6.5, ♀, 7; of tegmina, ♂, 36-36, ♀, 35-37; of posterior femora, ♂ and ♀, 30-31; of ovipositor, 11.5-13 mm. Width of tegmina, 11-12 mm."

## THE HEAD

Figures 1-8, 11

The head of *A. oblongifolia* is of the hypognathous type. Viewed from the front the head capsule and mouthparts are elongate-oval in outline (fig. 1), and under alcohol the surface appears smoothly polished.

**Head Capsule.**—The frons (*fr*) is a conspicuous area on the anterior portion of the epicranium.<sup>2</sup> Its limits, however, are not very clearly defined. When viewed exteriorly it appears to merge with the clypeus (*clp*) beneath it. Internally, however, there is a slight ridge (shown in fig. 1 by a dotted line) extending between the anterior tentorial pits (*atp*) demarking its lower limits. The upper limits of the frons are demarked by the lower mesal margins of the eyes, the basal and mesal margins of the antennal sclerites (*asc*) and the anterior margin of the fastigium (*fst*). The small dotted area (*ma*) in the upper portion of the frons represents a conspicuous muscle attachment. Laterally the frons merges with the genae (*ge*) on each side of the head.

The genae are demarked ventrally by the subgenal sutures (*sgs*), dorsally by the temporal sutures (*ts*), and posteriorly by the postgenal sutures (*pgs*), while the posterior margin of the eyes and the frons demark the anterior limits. Those portions of the genal areas behind the eyes and immediately beneath the temporal sutures, are sometimes designated as the tempora (*te*). Beneath the subgenal sutures are

<sup>2</sup>The term "epicranium" is here used to designate the paired areas of the head and the frons, but not including the clypeus.

the subgenae (*sge*), variously called the basimandibulare and trochantin of the mandible. The postgenae (*pge*) lie behind the genae, from which they are separated by the postgenal sutures, while the postoccipital sutures (*pos*) demark their posterior limits.

The dorsal portion of the head capsule is the vertex (*vx*), a flattened anterior projection of which is set off as the fastigium (*fst*). No coronal suture is present to divide the vertex into two areas as is frequently the case in lower Pterygota. Likewise there is no occipital suture present which usually divides off the posterior region of the vertex into an occipital area, and such an area can only roughly be defined as the posterior region of the vertex.

When the head is removed and viewed from the rear (fig. 2) a large opening called the occipital foramen (*ocf*) is plainly visible. Surrounding this opening laterally and dorsally is a narrow sclerite, the postocciput (*po*), to the posterior margin of which the cervical membrane (*cm*) is attached. This sclerite is separated from the remainder of the eperanium by the postoccipital suture (*pos*), and is shown in fig. 2 in internal view since it is bent back upon the head capsule. A small portion of the posterior margin of the postocciput is produced on each side into a small, cup-like process, the occipital condyle (*oc*), to which is articulated the cervical sclerite (*lc*), (fig. 6).

**Tentorial Pits** (figs. 1 and 6).—Lying at the mesal extremity of each subgenal suture are the slit-like invaginations called the anterior tentorial pits (*atp*), sometimes termed the frontal pits; lying at the back of the head, between the postocciput and the postgenae at the ventral ends of the postoccipital sutures, are the prominent, elongated invaginations, the posterior tentorial pits (*ptp*), sometimes called the gular pits. Since there is no definite gular region in this form, however, the term "posterior tentorial pit" is preferable to "gular pit," and for sake of uniformity the term "anterior tentorial pit" is preferable, in this case, to "frontal pit."

**Eyes.**—The compound eyes (*e*) are conspicuous elongate-oval structures, projecting from the upper lateral portions of the head capsule. The number of facets in each compound eye approximates fifteen hundred. Ocelli are lacking.

**Antennae** (figs. 1 and 3).—The antennae, located next to the lower mesal margin of the eyes, are filiform in structure. They measure about 40 mm. in length and average between 160–170 segments. The basal segment of the antenna, or scape (*scp*), is roughly cylindrical and about twice as long as it is wide. Laterally its base is extended into a finger-like pivoting process (*ap*), while mesally its base is rounded into a ball-shaped structure (*bsc*). The second segment of the antenna, or pedicel (*pd*), is separated from the scape by a narrow circular membrane, within which it hinges. The pedicel is closely joined to the succeeding postpedicel (*ppd*), which represents the first segment of the flagellum of the antenna.

The base of the antenna is surrounded by an annular portion of the integument, known as the antennal sclerite (*asc*). It bears a projection near the base of the antenna termed the antennifer (*af*). Fig. 1 shows the antennal articulating area (*aar*), left by the removal of the left

antenna, to be a relatively small one. The remainder of the membranous area within the antennal sclerite serves as an antennal socket (*aso*) for the swivel action of the ball of the scape (*bsc*), while the antennifer serves as a pivotal structure for the pivoting action of the antennal pivot (*ap*). This combination gives the insect considerable freedom for forward, backward and rotating movements of its antennae.

*Clypeus and Labrum* (fig. 1).—The clypeus (*clp*) is a trapezoidal sclerite hanging by its longer base from the epicranium. Two narrow projections of its upper base merge laterally with the subgenae. There is no epistomal suture extending between the anterior tentorial pits to demark the clypeus from the frons.

The labrum (*lr*), attached to the lower base of the clypeus, is horse-shoe-shaped in outline. There is no suture between the clypeus and labrum. The boundary between the clypeus and labrum is demarked on the oral, or pharyngeal, surface by the tormae (*to*), to be described below.

*Epipharynx* (fig. 5).—The epipharynx is a median lobe present on the posterior oral surface of the labrum and clypeus. It may be divided into a preepipharynx (*pre*) and a postepipharynx (*poe*), found on the oral surfaces of the labrum and clypeus respectively. In the lateral angles between the clypeus and labrum there are thickenings, or ridges, termed tormae (*to*). These thickenings continue, somewhat less strongly, into the epipharyngeal region, and thus serve to demark the preepipharynx from the postepipharynx, as well as to demark the labrum from the clypeus.

*Mandible* (fig. 4).—The endognath (*eg*) is a basal internal shelf projecting inward and extending around the triangular basal portion of the mandible. Each of the sides of the triangle represents the base of one of the three surfaces of the mandible. There is an outer or lateral surface, and an anterior and posterior surface. The edges of the latter two surfaces meet mesally to form the gnathal edge of the mandible. The gnathal edge is divided into a distal or apical incisor region (*in*), used for tearing the food apart; an intermediate grinding region, or mola (*m*); and a basal region containing stiff, elongate bristles, termed the brush (*br*), or brustia.

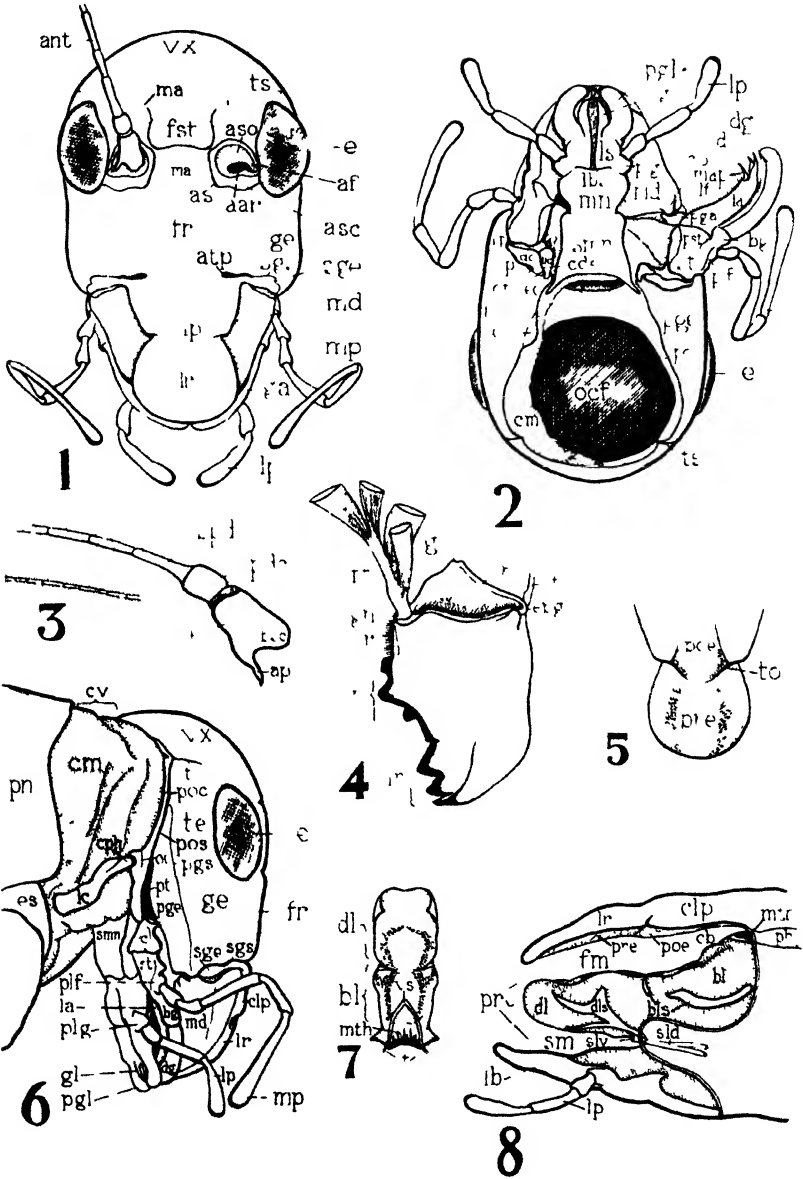
The epignath (*epg*) is a lateral prominence borne basally by the outer or lateral surface, to which the extensor tendon (*et*), of the muscles which open the mandible, is attached. At the base of the gnathal edge of the mandible is the gnathite (*gn*), which bears the flexor tendon (*ft*) to which are attached the muscles which close the mandible.

The posterior surface of the mandible bears a condyle (*co*) basally. When the mandible is viewed in position (fig. 2) it will be seen that the condyle articulates with a cup-shaped structure, the postgenal

#### EXPLANATION OF PLATE I

Head and associated structures of *Amblycorypha oblongifolia* (DeGeer). Figure 1. Anterior view of head. 2. Posterior view of head. 3. Basal and distal segments of antenna. 4. Posterior view of right mandible. 5. Under surface of labrum, showing epipharynx. 6. Postero-lateral view of head and cervix. 7. Dorsal, or anterior, view of hypopharynx. 8. Lateral view of mouth cavity.

(For explanation of abbreviations see pp. 190-92.)





acetabulum (*pga*), sometimes termed the postgenotheca, which is borne by the postgenal process (*pp*). The ginglymus (*g*) is a cup-shaped structure borne in an anterior projection, or pivoting point, which is itself borne basally by the anterior surface of the mandible. This process fits into a niche formed at the postero-lateral angle of the clypeus. The ginglymus, or cup-shaped structure within this process, itself receives a projection of the clypeal angle, and thus this process both projects and receives an articulating or pivoting point.

The extensor muscles attached to the extensor tendon exert a pull laterad of the articulating points, causing the mandible to open; while the flexor muscles attached to the flexor tendon exert a pull mesad of the articulating points and cause the mandible to close. The large size of the flexor tendon and the large muscles attached to it, adapt the insect mandible for the powerful crushing action of the closing mandible, whereas for the lesser task of merely opening the mandible a smaller tendon with small muscle attachments suffices.

**Maxilla** (fig. 2).—The basal segment of the maxilla is the cardo (*c*). This is divided by the cardinal suture (*cds*) into a basicardo (*bc*) and a *disticardo* (*dc*). The basicardo bears a saddle-shaped articulating process proximally, which is composed of an internal cardinal process (*cp*) and an external epicardo (*ec*). To the internal cardinal process a cardinal tendon (*ct*) is attached. The contraction of the muscles attached to this tendon causes the "saddle," formed by the internal cardinal process and the external epicardo, to ride or pivot over a niched ridge, sometimes termed the postoccipital process, beneath it (or actually dorsal to it).

Ventrad of the cardo is the maxillary stipes (*st*). Lying next to the stipes mesally, and separated from it by the parastipital suture (*psst*), is the parastipes (*pst*). The parastipital suture is the external manifestation of an internal ridge, or endostipes, to which the flexor muscles of the maxilla are attached.

Laterad of the stipes lies the palpifer (*plf*), a faintly demarked area which bears the five-segmented maxillary palpus (*mp*). Distally the stipes bears two lobes, a mesal lacinia (*la*) and an outer galea (*ga*). The lacinia bears a lacinial fringe (*lf*) along its inner margin and two tooth-like processes termed the lacinio-dentes (*ld*) at its apex, while just proximad of the lacinio-dentes is a moveable spine-like appendage called the midappendix (*map*). The galea is composed of two segments, a basigalea (*bg*) and a distigalea (*dg*), the latter partly concealing the lacinia.

**Labium** (fig. 2).—The labium or under lip is divided into a movable distal prelabium and a basal postlabium. The postlabium is a well sclerotized area composed of a distal mentum (*mn*) and a proximal submentum (*smn*), which is faintly, if at all, demarked from the mentum before it. The proximal angles of the submentum are closely associated with the ventral ends of the postocciput, and in this connection the latter is sometimes termed the trophifer.

The mentum is separated from the prelabium by the labial suture (*lbs*). The basal segments of the prelabium are composed of the labial stipites (*lst*) while laterad of the stipites are the palpifers (*plg*), which

bear the three-segmented labial palpi (*lp*). Distally the labial stipites bear the mesal lance-shaped glossae, and the outer fleshy paraglossae.

**Hypopharynx** (figs. 7 and 8).—The hypopharynx is composed of a distal region, or distilingua (*dl*), and a basal region, or basilingua (*bl*). The distal lobe of the hypopharynx is strengthened on each side by the distilingual sclerites (*dls*), each of which sends a narrow arm proximally to the opening of the salivary duct (*sld*), while the basal lobe is strengthened on each side by the presence of the basilingual sclerite (*bls*). The basilingual sclerite, which is a single continuous sclerite in the roach as shown by Crampton (1925), is separated in the present species into a relatively large basal sclerite and a small, narrow, distal sclerite, the latter demarking the distilingua from the basilingua. A narrow V-shaped sclerite (*vs*) borders the mouth opening anteriorly, and its arms continue internally to form a pair of tendons (*t*) for muscle attachment (fig. 7).

According to Snodgrass the cavity in which the hypopharynx lies is the preoral cavity (*prc*). That portion of the cavity between the hypopharynx and the epipharyngeal region is known as the food meatus (*fm*), while posteriorly between the hypopharynx and the inner surface of the labium lies the salivary meatus (*sm*). The proximal region of the food meatus is termed the cibarium (*cb*) and leads into the true mouth (*mlh*), which in turn leads into the pharynx region (*phy*) of the gut. The salivary meatus contains in its proximal portion a small sclerotized region termed the salivarium (*slr*), into which the salivary duct empties.

**Tentorium** (fig. 11). Fig. 11 is a posterior view of the head capsule showing the tentorium. Invaginations from the anterior tentorial pits (*atp*) extend posteriorly to form the anterior arms (*at*) of the tentorium, while invaginations from the posterior tentorial pits (*ptp*) extend anteromesally to form the posterior arms (*pt*). Where the fused posterior arms unite with the fused anterior arms, the corporotentorium (*cpt*), or eutentorium, is formed. A niche, or neuroforamen (*nf*), found anterior of the eutentorium, permits the circumoesophageal connectives to pass through from the brain to the suboesophageal ganglion. A furca-like invagination (*lf*) in the posterior portion of the corporotentorium, where the posterior arms unite, probably serves to give additional strength to the tentorium. No dorsal arms of the tentorium are present.

## THE THORAX

**Neck Region** (fig. 6).—Although the neck region, or cervix (*cr*), is here taken up with the thorax, it should be remembered, as Snodgrass, Crampton and others have suggested, that the neck is probably derived from portions of both the labial and prothoracic segments. The greater part of the cervix consists of the cervical membrane (*cm*) which bears on each side a lateral cervical sclerite (*lc*). The anterior portion of each lateral cervicale is differentiated into a knob-like cephaliger (*cph*), which articulates with the occipital condyle of the head, while the posterior portion articulates with a membranous fold just anterior to the episternum (*es*).

## PROTHORAX

*Pronotum* (fig. 22).—The pronotum (*pn*) is a saddle-shaped structure which covers the prothorax dorsally and laterally. The upper, dorsal surface is termed the disc (*dsc*), while the lateral portions are called the lateral lobes (*ll*). Each lateral lobe has overgrown most of the episternum (*es*<sub>1</sub>) and the epimeron (*ep*<sub>1</sub>), but while it has fused with the greater portion of the latter it has fused only marginally with the episternum. Dorsally the rounded posterior portion of the disc partially covers the scutum of the mesothorax. The surface of the pronotum is smooth, but each lateral lobe contains two pronotal sutures, or sulci (*su*), the anterior of which is continued into the region of the disc.

*Propleuron* (fig. 22).—Only a small ventral portion of the pleuron is visible just below the rounded, marginal edge of the lateral lobe of the pronotum. It is demarked by the pleural suture (*pls*<sub>1</sub>) into an anterior episternum (*es*<sub>1</sub>), and a posterior epimeron (*ep*<sub>1</sub>). A narrow portion of both the episternum and epimeron continues downward along the pleural suture to form a pleural articulation (*a*) for the coxa (*cx*).

Under the lateral lobe of the pronotum is a thin sclerotic continuation of the episternum, while the major portion of the epimeron has become fused with the pronotum. A narrow, thick sclerotization of the epimeron continues upward along the furrow formed by the pleural suture. The extent of these areas beneath the lateral lobe of the pronotum is shown in fig. 22, by broken lines. The above substantiates the view of Crampton, and Duporte, that in the Orthoptera the pronotum has overgrown the pleuron, rather than that the pronotum has forced out the pleuron as some investigators would have us believe.

The region extending downward from the episternum (fig. 13) anterior to the coxa and the trochantin (*tn*<sub>1</sub>), and united ventrally with the sternum, is the precoxal bridge or precoxale (*pcx*<sub>1</sub>), while the narrow sclerite behind the coxa which unites ventrally with the sternum and dorsally with the peritreme (*plr*) of the first thoracic spiracle, is the postcoxal bridge, or postcoxale (*pocx*<sub>1</sub>).

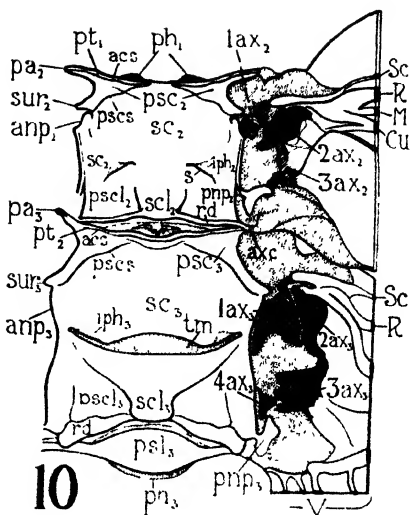
The trochantin (*tn*<sub>1</sub>) is a small sclerite forming a point of articulation for the leg (*b*), between the precoxale and the coxa.

*Fore Leg*.—The fore leg is shown in fig. 17, while its articulation with the pleuron can best be seen in fig. 22. The proximal leg segment, or coxa (*cx*), articulates with the pleural leg process (*plp*) at *a* and with the trochantin at *b* (fig. 13). A coxal spine (*cxsp*) is borne by the coxa just beneath the pleural articulation. The meron (*mr*) is represented by a small area. A more detailed discussion of the morphology of the coxa will be taken up under the discussion of the hind leg.

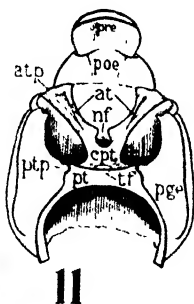
## EXPLANATION OF PLATE II

*Amblycorypha oblongifolia* (De Geer). Figure 9. Ventral view of left wing bases. 10. Dorsal view of mesothorax and metathorax, with right wing bases. 11. Posterior view of head capsule, with mouthparts removed, showing tentorium. 12. Ventral view of vannal area of left wing of male, showing file of rasping vein. 13. Ventral view of thorax. 14. Dorsal view of vannal areas of tegmina of male, showing stridulating mechanism.

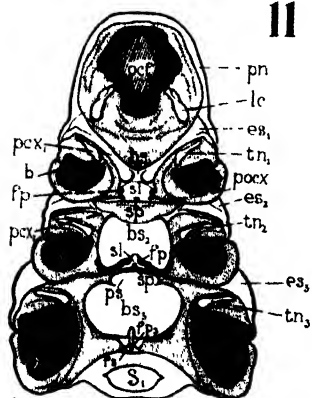
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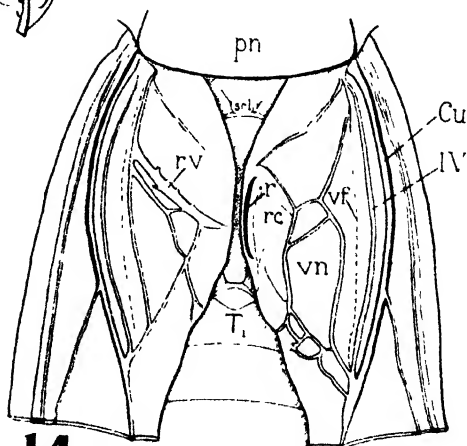
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12



13



14

neck-like projection of the first axillary abuts against the base of the subcostal vein (*Sc*). The second axillary abuts against the common base of the radial and medial veins (*R* and *M*) anteriorly, while posteriorly it articulates with the anterior projection of the third axillary (*3ax<sub>2</sub>*). The third axillary forms the posterior wing articulation with the posterior notal wing process (*pn<sub>2</sub>*).

**Fore Wing** (fig. 16).—The fore wing is elongate-oval in outline, and is termed the tegmen. Numerous cross-venules (not shown) give it a thickened leathery texture.

No distinct costal vein was found to arise from the basal trunk. The subcosta (*Sc*), whose base abuts against the neck of the first axillary, runs for a short distance and then branches to merge with the numerous venules. The radius (*R*) continues as a single vein with no branches to the apical margin of the wing, while the media (*M*) is four-branched. The cubitus (*Cu*) divides proximally into two branches, the anterior branch dividing into a number of sub-branches, while the posterior branch runs along the hind margin of the wing and meets the anterior sub-branches. The first anal vein, or vannal vein (*1V*) of Snodgrass is prominent. Immediately behind the first vannal vein is the vannal fold (*vf*) which divides the tegmen into a large anterior remigial region (*rm*), and a relatively small posterior vannal region (*vn*) which folds over the tergum of the thorax.

When the tegmina are folded in place, their color and the position of the veins might readily lead to their being mistaken for the color and venation of a leaf.

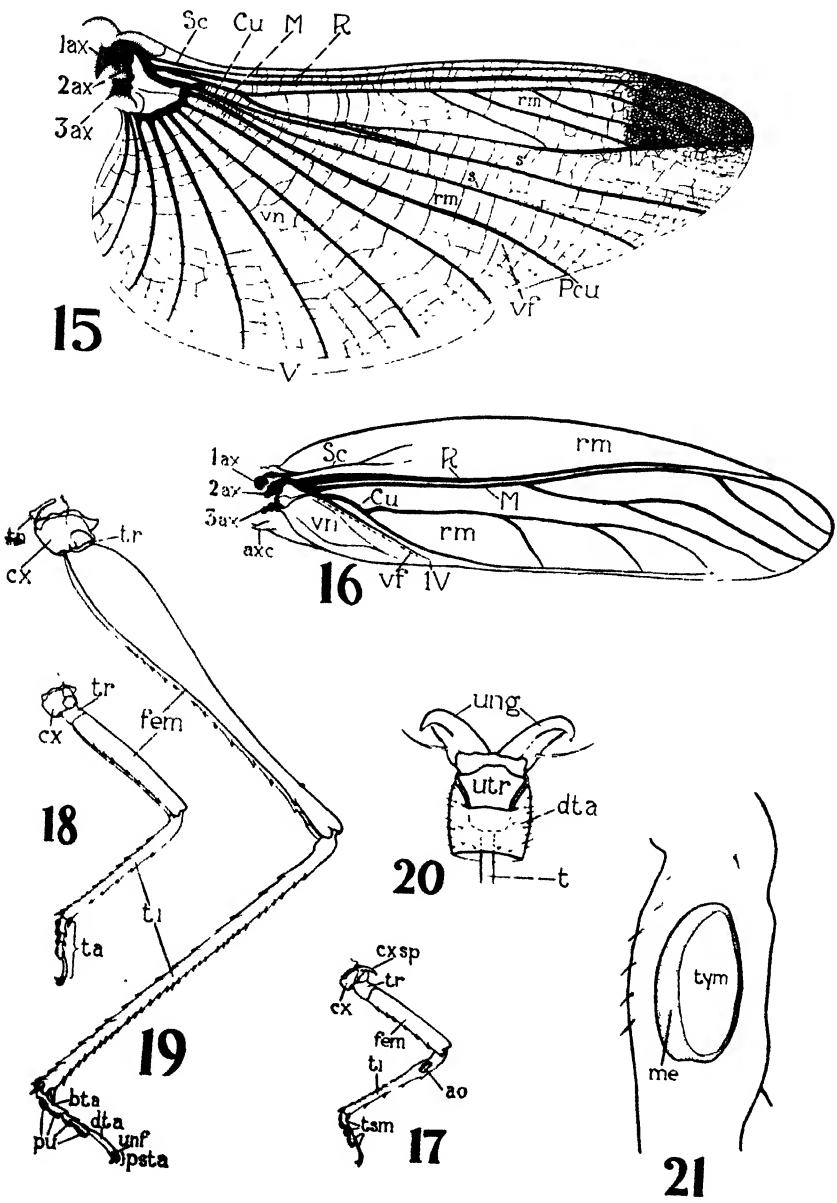
**Stridulating Mechanism** (figs. 12 and 14).—The vannal region of the fore wings of the male katydid bears the stridulating mechanism. The vannus of the left wing almost invariably folds over the vannus of the right wing. Submarginally the right vannus bears a dorsal rasp (*r*), or knife-edged sclerotization. Laterad, or actually anterior, of this rasp the surface of the wing contains a concave area which acts as a resonating chamber (*rc*). The vannus of the left wing bears a rasping vein (*rv*), which is seen in fig. 12 to bear a file-like sclerotization ventrally, which may be termed the file (*f*). As the fore wings are expanded and brought back into place, the rasp (*r*) on the dorsal surface of the right wing moves along the file (*f*) on the ventral surface of the left wing, producing the stridulation which is amplified and resonated by the resonating chamber (*rc*) located in the right wing.

**Alaria**.—Fig. 9 shows the ventral articulation of the wing base with the pleuron. There are usually present in this area a number of small sclerites which serve for the insertion of important wing muscles, termed the alaria by Crampton. These sclerites are the epipleurites of Snodgrass.

#### EXPLANATION OF PLATE III

Wing and leg structures of *Amblycorypha oblongifolia* (De Geer). Figure 15. Hind wing of female. 16. Fore wing of female. 17. Fore leg. 18. Middle leg. 19. Hind leg. 20. Ventral view of posttarsus of hind leg. 21. Enlarged view of "car" of fore leg.

(For explanation of abbreviations see pp. 190-92.)



Anterior to the pleural wing process ( $pw\phi_2$ ) is the basalare ( $ba_2$ ), while above the pleural wing process is the intralare ( $2ax_2$ ) of Crampton which represents the ventral sclerotization of the second axillary. This latter sclerite pivots upon the pleural wing process in the movement of the tegmina. No subalare sclerite is present in the mesothorax.

**Mesopleuron** (figs. 13 and 22).—The major portion of the pleuron is occupied by the episternum ( $es_2$ ) and the epimeron ( $ep_2$ ) which are separated by the pleural suture ( $pls_2$ ). The episternum and the epimeron continue along the pleural suture dorsally to give rise to the pleural wing process ( $pw\phi_2$ ), while their continuation along the pleural suture ventrally forms the pleural leg process ( $pl\phi_2$ ).

The anterior ventral portion of the episternum joins the narrow precoxale ( $pcx_2$ ), the latter joining with the basisternum ventrally (fig. 13).

Anterior to the episternum, in the intersegmental membranous area, is a large cavity which is partly covered by the pronotum (fig. 22). At the lower anterior margin of this large cavity is a much smaller spiracular opening. These two openings together constitute the double, first thoracic spiracle ( $spi_2$ ) which properly belongs to the mesothorax. The larger of these openings sends off a large tracheal branch into the fore leg, while the smaller of these openings sends off a small tracheal branch into the body cavity. This double spiracle is located in a sclerotized area termed the peritreme ( $ptr$ ).

Snodgrass has shown that the first thoracic spiracle in *Dissosteira* has a corresponding double tracheation, and therefore gives the appearance outwardly of an apparent double opening. In the katydid the posterior of these openings has become greatly developed and specialized into an "acoustic" trachea with its own separate opening, so that the apparent double spiracular opening of *Dissosteira* has become in actuality a double opening in *Amblycorypha*.

**Middle Leg** (fig. 18).—The mesothoracic leg is slightly larger than the fore leg, and except for the absence of an auditory organ is similar to the fore leg.

No coxal spine, however, is present on the coxa ( $cx_2$ ) of the middle leg and the meron ( $mr$ ) is somewhat more developed than that of the fore leg. The coxa articulates with the short trochanter ( $tr$ ), which is joined to the femur ( $fem$ ). The femur is grooved beneath and the outer edge of the groove is armed with spines. Following the femur, and slightly longer than it, is the tibia ( $ti$ ). The tibia is square in cross-section and each of its four edges is armed with spurs. The four-segmented tarsus ( $ta$ ) and the posttarsus ( $psla$ ) are almost identical with those of the fore leg.

**Mesosternum** (fig. 13).—The greater portion of the sternal sclerotization is occupied by the basisternum ( $bs_2$ ). The basisternum is considerably depressed medially, the lateral edges being raised above the surrounding membranous area, while its posterior lobes jut back toward the metasternum. Lying below the plane of the basisternum, and at an angle to it, is the sternellum ( $sl_2$ ), which is the furcasternum and spinasternum combined. The sternellum bears the furcal pits ( $f\phi_2$ ), each of which gives rise to an internal furca, or apophysis, and the spinal

pit ( $sp_2$ ) which invaginates internally into a pair of narrow lateral arms and a pair of short, posterior, horn-like arms, collectively making up the spina

#### METATHORAX

Correlated with the presence of large jumping legs and active organs of flight, the metathorax is the largest and most highly developed of the thoracic segments.

*Metanotum* (figs. 10 and 22). The narrow pretergite ( $pl_2$ ) of the metanotum actually belongs to the notum of the preceding segment and enters into the formation of the postnotum, or postscutellum of the mesothorax, when the latter is well developed. In the membranous area anterior to the pretergite are two small sclerites ( $\tau$ ) which may possibly represent vestiges of the postscutellum. The pretergite is separated by an antecostal suture ( $acs$ ) from the prescutum ( $psc_3$ ) which follows it. The antecostal suture, as in the preceding mesothoracic segment, gives rise to a pair of inflections or lobes, termed the second phragma ( $ph_2$ ), which serve for muscle attachment. Behind the prescutal suture ( $psc_s$ ) lies the large scutum ( $sc_3$ ). A transverse membranous area ( $tm$ ) extends across the scutum, and there is present internally at each end of the membranous area a lobe, or interphragma ( $iph_3$ ), which serves for muscle attachment. The presence of both the transverse membrane and the interphragma would permit an arching and depressing action of the notal plate and this action may possibly play a role in the movement of the hind wings.

Behind this transverse membrane, medially, lies the scutellum ( $sl_3$ ) which is flanked on either side by a depressed area, the parascutellum ( $pscl_3$ ), which latter region is a part of the scutum. The posterior region of the notal plate folds under itself to give rise to the reduplication ( $rd$ ). The reduplication is separated by a narrow membranous area from the postnotum, or postscutellum ( $psl_3$ ), the posterior inflection of which gives rise to the third phragma ( $ph_3$ ).

There are present in the metanotum a number of lateral projections as is the case in the mesonotum. There are the prealare ( $pa_3$ ), the suralare ( $sur_3$ ), the anterior notal wing process ( $anp_3$ ) and the posterior notal wing process ( $pnp_3$ ), whose functions are similar to those described for the mesothorax.

*Pteralia* (fig. 10). The first axillary ( $1ax_3$ ) articulates with the suralare ( $sur_3$ ) and the anterior notal wing process ( $anp_3$ ) mesally, and with the second axillary ( $2ax_3$ ) laterally, while an anterior neck-like projection of the first axillary abuts against the base of the subcosta ( $Sc$ ). The second axillary merges with the common base of the radius ( $R$ ) and media ( $M$ ) anteriorly, while posteriorly it articulates with the third axillary ( $3ax_3$ ). The latter articulates with the fourth axillary ( $4ax_3$ ), which probably represents a detached portion of the posterior notal wing process ( $pnp_3$ ) and in this case the fourth axillary articulates with the posterior notal wing process.

*Hind Wing* (fig. 15).—The hind wing is the active flight organ of the katydid. It is divided by the vannal fold ( $vf$ ), according to Snodgrass, into an anterior remigial region ( $rm$ ) and a posterior vannal



region (*vn*). A number of secondary folds (*sf*) are present in the remigium. The tip of the hind wing, protruding from behind the tegmina, contains numerous venules which give it a tegmen-like texture. The vannal region is a thin membranous region, and it likewise contains a secondary fold (not shown) between each vannal vein which enables it to fold like a fan.

The veins of the hind wing are derived from a common V-shaped trunk, with its apex pointing toward the tip of the wing. The first vein arising from this trunk is the concave subcosta (*Sc*). This is followed by the convex radius (*R*) which branches twice near its distal extremity. The media (*M*) branches twice proximally; the anterior branch divides into a number of sub-branches, while the posterior branch of media divides into two sub-branches and the posterior of these two fuses with the first branch of the cubitus. The cubitus (*Cu*) arises from the apex of the V-shaped trunk and almost immediately divides into two branches. Behind the cubitus there is present the postcubitus (*Pcu*) of Snodgrass, which is the first anal vein of Comstock. Following it are the vannal veins (*V*) of Snodgrass or anal veins of other authors, which arise as convex veins but become concave halfway toward the margin of the wing.

*Alaria* (fig. 9).—There are two basalar sclerites (*ba<sub>s</sub>*) present at the ventral base of the wing. The anterior of these is joined to the episternum (*es<sub>3</sub>*) and indicates their probable origin as detached portions of the pleuron. Above the pleural wing process (*pw<sub>p</sub>*) is the intralare (*2ax<sub>3</sub>*) or the ventral sclerotization of the second axillary, which serves as a pivoting structure for the wing. Posterior to the pleural wing process there is present an elongate subalare sclerite (*sa<sub>3</sub>*). It is not definitely known whether the subalare is likewise of a pleural origin, as Snodgrass claims, or whether it arises as an independent sclerotization between the epimeron and the wing base.

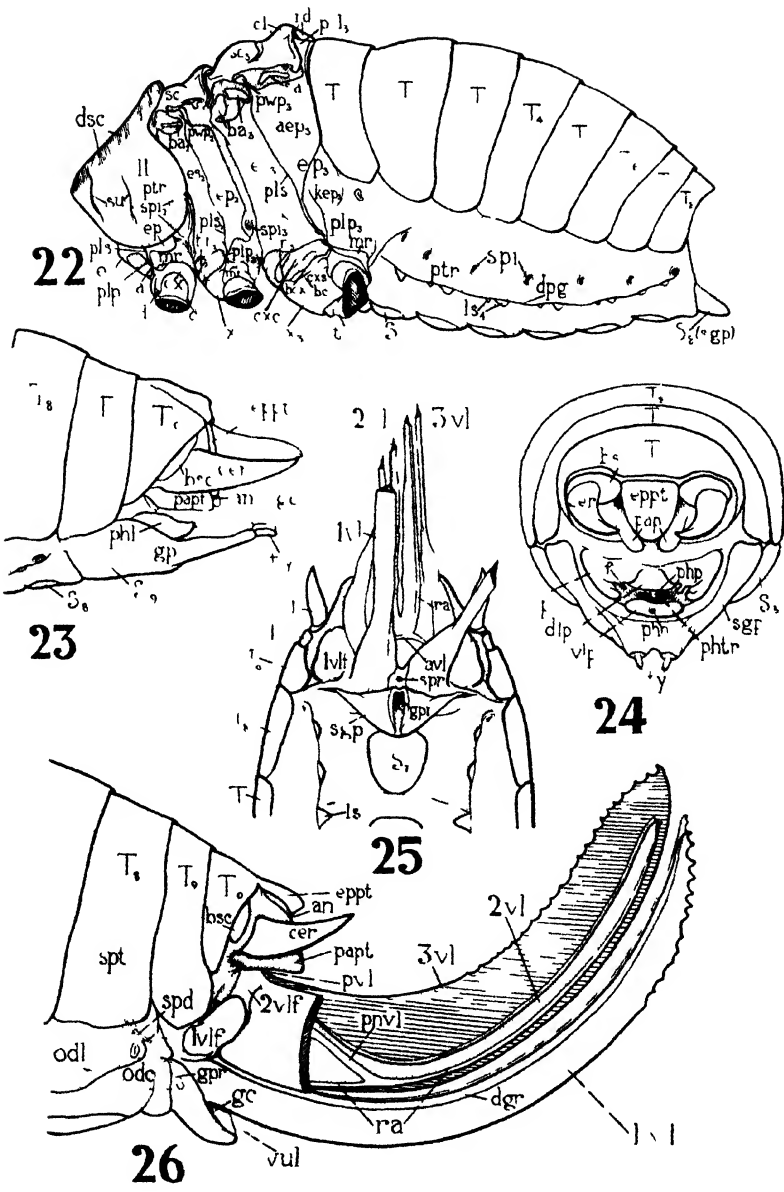
*Metapleuron* (fig. 22).—Along with the enlarged size of the metathorax we find that the metapleuron is larger than that of the mesopleuron. The episternum (*es<sub>3</sub>*) is separated by the pleural suture (*pls<sub>3</sub>*) from the epimeron (*ep<sub>3</sub>*), which is divided into a broad upper anepimeron (*aep<sub>3</sub>*) and a lower katepimeron (*kep<sub>3</sub>*). A dorsal continuation of the episternum and epimeron along the pleural suture gives rise to the pleural wing process (*pw<sub>p</sub>*), while a ventral continuation of the same sclerites along the pleural suture forms the pleural leg process (*plp<sub>3</sub>*). The second thoracic spiracle (*spt<sub>3</sub>*) has migrated forward so that it is closely associated with the epimeron of the mesothoracic segment. Both precoxal and postcoxal bridges are lacking. The trochantin (*tn<sub>3</sub>*) is similar to that of the preceding segment.

*Hind Leg* (figs. 19 and 22).—According to Snodgrass the proximal end of the coxa (*cx<sub>3</sub>*) is girdled by a submarginal basicostal suture (*bcs*),

#### EXPLANATION OF PLATE IV

Abdominal structures of *Amblycorypha oblongifolia* (De Geer). Figure 22. Lateral view of thorax and abdomen. 23. Lateral view of male terminalia. 24. Posterior view of male terminalia showing phallus. 25. Ventral view of female terminalia, with subgenitalia plate pulled back. 26. Lateral view of ovipositor.

(For explanation of abbreviations see pp. 190-92.)



which forms internally a ridge and sets off a marginal region, or basicoxite (*bcr*). The coxal suture (*cxs*) falls in line with the pleural suture, dividing the coxa into two parts. The coxal suture likewise divides the basicoxite into a prearticular portion and a postarticular portion. The postarticular portion is termed the meron (*mr*) and the suture which sets it off is a continuation of the basicostal suture. The meron is best developed in the hind leg. The coxa articulates with the pleural leg process and with the trochantin, while the articular membrane which surrounds its base is termed the coxal corium (*cxc*).

The trochanter (*tr*) is reduced to a narrow annular sclerite, barely visible from the outer view. The femur (*fem*) is broadly developed at its proximal portion and contains the muscles used in jumping. The under surface is grooved and the inner edge is armed with spines. The tibia (*ti*) is similar to that of the preceding segment and is heavily armed with spines on all four of its margins. The tarsus (*ta*) and posttarsus (*psla*) has been described for the prothoracic leg.

*Metasternum* (fig. 13).—The basisternum (*bsa*) is larger than that of the preceding segment and the posterior lobes are rounded, while an anterior portion has become sclerotized to form the presternum (*psa*). The furcasternum (*fs*) which follows contains a common furcal pit (*fpa*) which gives rise to the furcal invagination. Internally this common furcal pit branches shortly, and each branch in turn gives off two sub-branches. According to Snodgrass no spinasternum is ever present in the metathoracic segment of insects (although it does occur in the metasternum of *Grylloblatta*).

## ABDOMEN

Figures 22-26

In the following discussion of the abdomen the writer has attempted to follow Snodgrass as closely as possible in the terminology used to designate the regions of the abdomen and its various parts. Thus, considering the body as a whole, the back and sides above the limb bases is the dorsum and the undersurface between the limb bases is termed the venter, while the region of the limb bases themselves are termed the pleural areas. Each major segmental plate of the dorsum is termed the tergum; each major segmental plate of the venter is termed a sternum, and each major sclerotic plate of the pleural area is termed a pleuron.

If we likewise follow Snodgrass in the opinion that in the generalized segments of most insects the spiracles lie in the sides of the segments above the region of the limb bases, or in the lateral parts of the dorsum, then the groove below the spiracles is the dorso-pleural groove (*dpg*). The region above the dorso-pleural grooves is the dorsum of the abdomen, while the region beneath the dorso-pleural groove is the combined regions of the abdominal venter and the abdominal pleural areas.

The pregenital region of the abdomen, containing seven segments in the female and eight segments in the male, is discussed collectively under the heading of visceral segments, while the genital and post-

genital segments are considered separately under the discussion of the male and female terminalia.

#### VISCERAL SEGMENTS

A lateral view of the female abdomen is shown in fig. 22. It comprises by far the greatest volume of the insect body, reaching its greatest cross-section about the region of the third abdominal segment, then gradually tapering posteriorly. With little exception, the structure of the visceral segments is fairly uniform throughout.

*Abdominal Terga* (figs. 22-26).—The abdominal terga ( $T_1$ ,  $T_2$ , etc.) are the major sclerotized plates of the dorsum of the abdomen. Each segmental area of the dorsum consists of a saddle-shaped tergal plate, followed by a wide, posterior membranous area which is folded beneath the posterior portion of the tergal plate, producing a telescoping effect. In the strictest sense of the word, however, each "segmental" tergum consists of a narrow, weakly sclerotized pretergal, or acrotergal area, demarked by an antecostal suture, which area actually belongs to the preceding segment. The antecostal suture forms an internal ridge, or antecosta, which serves for muscle attachment.

The pretergite of the first abdominal tergum is well developed and enters into the formation of the postnotum, or postscutellum ( $psl_3$ ) of the metathoracic segment, as was mentioned in the discussion of the thorax, and the posterior inflection of the postscutellum forms the third phragma serving for muscle attachment. In each succeeding tergal plate, however, the pretergite is poorly defined and merges with the membranous area preceding it.

*Spiracles* (fig. 22). There are eight pairs of abdominal spiracles ( $spi$ ) which lie in the thickened membranous region of the dorsum above the dorso-pleural groove. Each spiracular opening lies in a small sclerotic area termed the peritreme ( $ptr$ ).

*Abdominal Sterna and Laterosternites* (figs. 22, 23, 25).—Beneath the dorso-pleural grooves lie the combined regions of the abdominal venter and the abdominal pleural areas. Since no pleuro-ventral grooves are present, however, there is no way of distinguishing the pleural areas from the venter of the abdomen. The small triangular sclerites, immediately beneath the dorso-pleural groove, lie in the pleural region of the abdomen, but since there is no way of telling from this study alone whether these are derivatives of the primitive bases of abdominal appendages, secondary sclerotizations, or lateral subdivisions of the definitive pleurosterna, they are noncommittally termed laterosternites ( $ls$ ). These laterosternites, lying in a thickened membranous region, are present on the first seven abdominal segments.

Lying medially in this pleurosternal region are the major sclerotic plates of the venter. Each of the first seven abdominal segments of the venter consists of an anterior sternal plate or sternum ( $S_1$ ,  $S_2$ , etc.), followed posteriorly by a membranous area. The anterior margin of each sternal plate is inflected, forming an internal point for muscle attachment. The abdominal sterna gradually shift posteriorly in the female, so that the seventh sternum ( $S_7$ ) appears to lie beneath the eighth tergum.

## FEMALE TERMINALIA

Figures 25 and 26

The eighth and ninth segments of the female abdomen are adapted by structural and appendicular modifications to perform the genital functions, and are referred to as the genital segments, and are followed by the tenth and eleventh segments which are the postgenital segments. The genital and postgenital segments together with their appendages comprise the terminalia.

*The Eighth Segment.*—The eighth tergum ( $T_8$ ) differs little from the visceral terga preceding it. The pleural area, however, contains a sclerotized portion which forms the first valvifer ( $1\text{ }vlf$ ). The anterior portion of the first valvifer, which has shifted ventrally, bears the long, curved, blade-like structures which are the first, or ventral valvulae ( $1\text{ }vl$ ) of the ovipositor. (The ovipositor of Orthoptera consists of three pairs of valvulae, a first, second and third pair, although in Acrididae and Gryllidae the second pair may be reduced or rudimentary. In other insects which bear an ovipositor, such as Thysanura, Hemiptera and Hymenoptera, there are only two pairs of valvulae and these are the first and second pairs.) The upper, outer margin of the first valvula contains a dorsal groove ( $dgr$ ) which interlocks with the ventral edge of the third, or dorsal valvula ( $3\text{ }vl$ ), while the ventral margin of the first valvula is strongly toothed apically. The posterior, or upper portion of the first valvifer bulges and overlaps a basal portion of the dorsal valvula.

The eighth sternum ( $S_8$ ) forms a triangular, subgenital plate ( $sgp$ ) which underlies the bases of the first valvulae. Between the ventral bases of the first valvulae and the dorsal surface of the subgenital plate, there is formed a genital chamber ( $gc$ ).

Fig. 25 shows a ventral view of the female terminalia with the subgenital plate pulled back anteriorly, exposing the genital chamber. The genital chamber is an external pouch, or pocket, formed between the ventral bases of the first valvulae and the dorsal surface of the eighth sternum. The median gonopore ( $gpr$ ), which is the true external genital opening, is located anteriorly on the floor of the genital chamber, which floor forms the dorsal surface of the subgenital plate. The posterior opening of the genital chamber, which receives the male spermatophore, is termed the vulva ( $vul$ ). The gonopore is the opening of the median oviduct ( $odc$ ) (shown by broken lines in fig. 26) into which the paired lateral oviducts ( $odl$ ) discharge. The membranous lips of the gonopore continue posteriorly along the dorsal surface of the subgenital plate, and form a membranous subchamber, within the genital chamber. Located on the roof of the genital chamber, between the bases of the ventral valvulae, is the minute spermathecal aperture ( $spr$ ), which leads through a narrow spermathecal duct ( $spd$ ) into the sac-like spermatheca ( $spt$ ) in which the female stores the sperm after copulation.

It should be noted that the eighth sternum, or subgenital plate, and the first valvifers have shifted posteriorly, and appear to be more closely associated with the ninth tergum than with the eighth tergum to which they actually belong.

*The Ninth Segment.*—The ninth tergum ( $T_9$ ) is somewhat narrower than the eighth tergum, and its antecostal ridge is strongly developed, particularly along its lateral portions, serving for the attachment of the muscles associated with the ovipositor.

The pleural area of the ninth segment is represented by the reduced second valvifers ( $2\ vlf$ ). The anterior portion of the second valvifer gives rise to the second, or inner valvulae ( $2\ vl$ ) of the ovipositor, while the posterior portion of the second valvifers bears the third, or dorsal valvulae ( $3\ vl$ ). This relationship of the inner and dorsal valvulae to the second valvifer is not altogether evident outwardly, since the aides of the dorsal valvulae have grown down about the inner valvulae and the latter have been displaced posteriorly. The relationship of the parts of the ovipositor is further obscured in the adult by the fact that the ventral bases of the inner valvulae have fused with the bases of the dorsal valvulae (fig. 26) and the second valvifers have been displaced dorsally by the first valvifers. If careful study is given to the development of the ovipositor in this family, however, the true relationship of the parts of the ovipositor to one another becomes clear, as has been shown by Walker, Snodgrass and others.

The bases of the inner valvulae are fused with one another, and are in turn fused with the bases of the dorsal valvulae. The fused bases are strengthened and united by a narrow transverse sclerotic bar, or anterior intervalvula ( $avl$ ) (fig. 25). Laterally this bar unites with the dorsal valvulae, and further sends two sclerotic continuations posteriorly along the ventral edges of the inner valvulae, which are termed the rami ( $ra$ ). Each ramus sends a sclerotic continuation or pons valvulorum ( $pvl$ ) anteriorly along the outside of the inner valvulae which unites dorsally and meet a narrow transverse, termed the posterior intervalvula ( $pvl$ ), at the dorsal base of the inner valvulae. Where the united pons valvulorum meets the posterior intervalvula, there is a pit-like invagination which gives rise to an internal apodeme which serves for muscle attachment. The lateral extremities of the posterior intervalvula unite with the dorsal valvulae.

The dorsal valvulae which enclose the inner valvulae are the broadest blades of the ovipositor. The upper edges are sharply toothed posteriorly, while the ventral edges are smooth and lock with the dorsal grooves of the ventral valvulae.

Briefly the passage of the egg from the female may be summarized as follows. The egg passes down the lateral oviduct ( $odl$ ) into the median oviduct ( $odc$ ) and out through the gonopore ( $gpr$ ). As the egg passes out through the gonopore, into the subgenital chamber, it is fertilized by one of the sperm which is pumped out through the spermathecal aperture ( $spr$ ). The lips of the gonopore which extend posteriorly apparently guide the egg between the ventral valves, down which it passes before being inserted into the ground. It should be noted that the deposition of eggs into the ground is unique among the Phaneropterinae, the edges of leaves and twigs being the usual depository. The following account of Hancock is taken from Blatchley (1920, p. 479): "When ready to oviposit . . . the female curves her abdomen, which is now distended with eggs, forward underneath her body and at the same time seizes the end of the large ovipositor in her mandibles.

In this way she directs its point to the desired point in the ground. Then she forces or drills a hole in the earth for the reception of each egg or cluster of eggs."

*The Tenth Segment.*—The tenth tergum ( $T_{10}$ ) is greatly reduced and narrowed. Medio-dorsally it unites with the eleventh tergum, or epiproct, although a constriction remains at each side to demark its former limits. The antecostal ridge is well developed. The tenth segment lacks appendages and the venter is entirely membranous and reduced.

*The Eleventh Segment.*—The eleventh segment bears the anus (*an*) posteriorly. Its tergum forms the short, broad, supra-anal plate, or epiproct (*eppt*), while the ventro-lateral parts of the segment form two membranous lobes, or paraprocts (*papt*), on each side of the anus.

Below the epiproct, and almost immediately behind the tenth tergum, is the single-segmented cercus (*cer*), which, though it appears to be borne by the tenth segment, is a recognized appendage of the eleventh segment. At the base of the cercus is a small sclerotized plate, or basi-cercus (*bsc*).

#### THE MALE TERMINALIA

Figures 23 and 24

Contrasted with the female, the male has only a single genital segment, or gonosomite, which is the ninth segment. The eighth segment thus remains a pregenital, or visceral segment and is similar to those segments as described in the female.

*The Ninth Segment.*—Apart from a slight difference in size, the ninth tergum ( $T_9$ ) differs but little from the preceding visceral segments.

The ninth sternum ( $S_9$ ) enters into the formation of the male subgenital plate (*sgp*), which bears a pair of styli (*sty*) posteriorly (fig. 23). It is apparent from the presence of the styli, however, that the subgenital plate consists of the gonopod bases, which have shifted from their original pleural position and fused with the definitive sternal plate. The dorsal surface of the subgenital plate is concave and forms a genital chamber (*gc*) which contains the phallus (*phl*).

The phallus arises medially on the intrasegmental membrane of the ninth segment which has invaginated inward in the formation of the genital chamber. Fig. 24 shows a dorso-posterior view of the phallus. In its ordinary retracted state the phallus appears to be a short, broad, fleshy lobe within the genital chamber. Closer examination, however, reveals the phallus to consist of a dorsal lobe (*dlp*), a pair of large lateral lobes (*llp*), and a ventral lobe (*vlp*), which fold together tightly about the posterior opening of the phallus, or phallotreme (*phtr*). The ventral surface of the dorsal lobe bears a phallic papilla (*php*) posteriorly, which fits into a phallic notch (*phn*) on the ventral lobe, enabling the lobes to remain tightly locked together while the phallus is not in use. The phallotreme opens into the endophallic cavity which, in turn, opens anteriorly into the ejaculatory duct through the gonopore. The armature, or modified lobes, usually present on the dorsal surface of the dorsal lobe in the phallic organs of other Tettigoniids, is lacking.

The "flat, tongue-like fold that divides the endophallic cavity into a dorsal and ventral compartment," mentioned by Snodgrass (1937, p. 67), is probably the fold (*f*) borne by the lateral lobe, which serves to lock the lateral lobes with the lateral edges of the dorsal lobe when the phallus is retracted. The writer was able to view the phallus of a specimen containing a spermatophore, which when removed left the phallus in a protracted state and there was apparently no functional division of the endophallic cavity into two compartments. It should be noted that the phallus is used to form the spermatophore, and is not an intromittent organ.

*The Tenth Segment.*—The tenth tergum ( $T_{10}$ ) suffers a reduction in size. Dorsally it contains a triangular median depression. The pleurosternal area of the tenth segment is greatly reduced and is represented by the membranous region above the phallus.

*The Eleventh Segment.*—The eleventh tergum forms the epiproct (*eppt*) above the anal opening. In the male the epiproct is bent sharply downward. The anus is flanked on each side and somewhat ventrally by the paraprocts (*papt*). The eleventh segment bears the cerci (*cer*), which in the male are curved inward and may possibly have a clasping function. The sclerotic area at the base of the cercus is the basiscercus (*bsc*).

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## EXPLANATION OF ABBREVIATIONS

- |  |   |
|--|---|
| <i>a</i> ... pleural leg articulation.       | <i>bc</i> ... basicardo                                       |
| <i>aar</i> ... antennal articulation area    | <i>bcs</i> ... basicostal suture                              |
| <i>acs</i> ... antecostal suture             | <i>bcx</i> ... basicoxite                                     |
| <i>aep</i> ... anepimeron                    | <i>bg</i> ... basigalea                                       |
| <i>af</i> ... antennifer                     | <i>bl</i> ... basilingua                                      |
| <i>an</i> ... anus                           | <i>bis</i> ... basilingual sclerites                          |
| <i>anp</i> ... anterior notal wing process   | <i>br</i> ... brustia, or brush of mandible                   |
| <i>ao</i> ... auditory organ                 | <i>bs</i> ... basisternum                                     |
| <i>ap</i> ... antennal pivoting process      | <i>bsc</i> ... ball of scape (Plate I); basicercus (Plate IV) |
| <i>asc</i> ... antennal sclerite             | <i>bla</i> ... basitarsus                                     |
| <i>aso</i> ... antennal socket               |   |
| <i>at</i> ... anterior tentorial arm         | <i>c</i> ... cardo  |
| <i>atp</i> ... anterior tentorial pit        | <i>cb</i> ... cibarium  |
| <i>avl</i> ... anterior intervalvula         | <i>cds</i> ... cardinal suture                                |
| <i>1 ax</i> ... 1st axillary                 | <i>cer</i> ... cercus   |
| <i>2 ax</i> ... 2nd axillary                 | <i>clp</i> ... clypeus  |
| <i>3 ax</i> ... 3rd axillary                 | <i>cm</i> ... cervical membrane                               |
| <i>4 ax</i> ... 4th axillary                 | <i>co</i> ... condyle   |
| <i>axc</i> ... axillary cord                 | <i>cp</i> ... internal cardinal process                       |
|  | <i>cph</i> ... cephaliger                                     |
| <i>b</i> ... trochantal articulation of coxa | <i>cpt</i> ... corporoventerium                               |
| <i>ba</i> ... basalare                       |   |

- ct*....cardinal tendon  
*Cu*....Cubitus, or cubital vein  
*cv*....cervix  
*cx*....coxa  
*cxc*....coxal corium  
*cxs*....coxal suture  
*cxsp*....coxal spine  
  
*d,d'*....coxo-trochanter articulations  
*dc*....disticardo  
*dg*....distigalea  
*dgr*....dorsal, interlocking groove of ovipositor  
*dl*....distilingua  
*dlp*....dorsal lobe of phallus  
*dls*....distilingual sclerite  
*dpg*....dorso-pleural groove  
*dsc*....disc of pronotum  
  
*e*....compound eye  
*ec*....epicardo  
*eg*....endognath  
*ep*....epimeron  
*epg*....epignath  
*eppl*....epiproct  
*es*....episternum  
*el*....extensor tendon  
  
*f*....file of rasping vein (Plate II); fold (Plate IV)  
*fem*....femur  
*fm*....food meatus  
*fp*....furcal pit  
*fr*....frons  
*fs*....furcasternum  
*fst*....fastigium  
*ft*....flexor tendon  
  
*g*....ginglymus  
*ga*....galea  
*gc*....genital chamber  
*ge*....gena  
*gn*....gnathite  
*gpr*....gonopore  
  
*in*....incisor region  
*iph*....interphragma  
  
*kep*....katapimeron  
  
*la*....lacinia  
*lb*....labium  
*lbs*....labial suture  
*lc*....lateral cervical sclerite  
*ld*....lacinio-dentes  
*lf*....lacinial fringe  
*ll*....lateral lobe of pronotum  
*llp*....lateral lobe of phallus  
*lp*....labial palpus  
*lr*....labrum  
*ls*....laterosternite  
*lst*....labial stipites  
  
*M*....Media, or medial vein  
*m*....mola  
*ma*....muscle attachment  
*map*....midappendix  
*me*....auditory membrane  
*mn*....mentum  
*mp*....maxillary palpus  
*mr*....meron  
*mlh*....mouth  
  
*nf*....neuroforamen  
  
*oc*....occipital condyle  
*ocf*....occipital foramen  
*odc*....median oviduct, or oviduct communis  
*odl*....lateral oviduct, or oviduct lateralis  
  
*pa*....prealare  
*pap*....postoccipital process  
*papl*....paraproct  
*pcu*....postcubitus  
*pcx*....precoxale  
*pd*....pedicel  
*pga*....postgenal acetabulum, or postgenotheca  
*pge*....postgena  
*pgs*....postgenal suture  
*ph*....phragma  
*phl*....phallus  
*phn*....phallic notch  
*php*....phallic papilla  
*phlr*....phallotreme  
*phy*....pharynx  
*plf*....palpifer  
*plg*....palpiger  
*plp*....pleural leg process  
*pls*....pleural suture  
*pn*....pronotum  
*pnp*....posterior notal wing process  
*pnl*....pons valvulorum  
*poc*....postocciput  
*pocx*....postcoxale  
*poe*....postepipharynx  
*pos*....postoccipital suture  
*pp*....postgenal process  
*ppd*....postpedicel  
*prc*....preoral cavity  
*pre*....preepipharynx  
*ps*....presternum  
*pse*....prescutum  
*psecl*....parascutellum  
*pssc*....prescutal suture  
*psl*....postscutellum, or postnotum  
*pst*....parastipes  
*psta*....posttarsus  
*psts*....parastipital suture  
*pt*....posterior tentorial arm (Plate I); pretergite (Plate II)  
*ptp*....posterior tentorial pit  
*plr*....peritreme of spiracle  
*pu*....pulvillus

*pvl*... posterior intervalva  
*pwp*... pleural wing process

*R*.... Radius, or radial vein  
*r*.... rasp  
*ra*.... ramus  
*rc*.... resonating chamber  
*rd*.... reduplication  
*rm*.... remigium  
*rv*.... rasping vein

*S*.... sternum  
*s*.... secondary suture  
*sa*.... subalare sclerite  
*Sc*.... Subcosta, or subcostal vein  
*sc*.... scutum  
*scl*.... scutellum  
*scp*.... scape of antenna  
*sf*.... secondary wing fold  
*sge*.... subgena  
*sgp*.... subgenital plate  
*sgs*.... subgenal suture  
*sl*.... sternellum  
*sld*.... salivary duct  
*slv*.... salivarium  
*sm*.... salivary meatus  
*smn*.... submentum  
*sp*.... spinal pit  
*spd*.... spermathecal duct  
*spi*.... spiracle  
*spr*.... spermathecal aperture  
*spt*.... spermatheca  
*st*.... stipes

*sty*.... stylus  
*su*.... sulci  
*sur*.... suralare

*T*.... tergum  
*t*.... tendon  
*ta*.... tarsus  
*te*.... temporal region  
*tf*.... tentorial furca, or pit  
*ti*.... tibia  
*tm*.... transverse notal membrane  
*tn*.... trochantin  
*to*.... tormae  
*tr*.... trochanter  
*ts*.... temporal suture  
*tsm*.... tarsomere  
*tym*.... tympanum

*unf*.... unguifer  
*ung*.... ungue, or claw  
*utr*.... unguitractor

*v*.... vestigial sclerites (of postnotum?)  
*V*.... vannal vein  
*vf*.... vannal fold  
*vl*.... valvula  
*vlf*.... valvifer  
*vlp*.... ventral lobe of phallus  
*vn*.... vannal region, or vannus  
*vs*.... V-shaped, surlingual sclerite  
*vul*.... vulva  
*vx*.... vertex

LYCAENIDAE OF THE ANTILLES (LEPIDOPTERA, RHOPALOCERA),  
 by WILLIAM P. COMSTOCK and E. IRVING HUNTINGTON. *Annals of the New York Academy of Sciences*, Vol. XLV, Art. 2, pp. 49-130; 1 plate, 1943. Published by the Academy.

This revision of a difficult group of butterflies from a complex faunal area differs refreshingly from many older works of its kind. One of its features is the early elimination of twenty names as unrecognized or extralimital, with discussion of past treatment where it has been important. Any taxonomist who has struggled with species named in older works and since inadequately identified will appreciate the wisdom and courage of this course, so strongly contrary to the burning taxonomic urge to sweep the field and pigeonhole every name.

From this point the bulk of the revision consists of the authors' systematic account. The reviewer is always unwilling to criticize specific treatment unless he has well supported opinions in the same group, which is not true here. The treatment appears to be careful, thorough and judicious in its evaluation of the available material. The prevalence of trinomials is a feature against which the reviewer continues to protest. Such subdivisions are a matter of opinion. They can be useful, but God forbid that we should go to the extremes that have been attained in the European fauna.

The final section is a brief but very interesting analysis of the interrelations of the insular and certain continental forms. And here, in conclusion, the writers express a laudable reluctance to pursue some fascinating zoogeographical temptations beyond the legitimate interpretation of the available evidence.

—A. W. LINDSEY.

# DOUTTIA, A NEW GENUS OF NEW HEBRIDEAN CURCULIONIDAE

(Coleoptera: Cryptorhynchinae)

ELWOOD C. ZIMMERMAN,

Bernice P. Bishop Museum,  
Honolulu, T. H.

Among some insects collected by Lt. R. L. Doutt, United States Air Force, while on duty in the southwest Pacific was a pair of weevils which represent a new genus and species. In spite of the exigencies of battle front conditions, Lt. Doutt made several collections of insects during spare moments, but all but one lot of specimens were lost. It is a pleasure to dedicate the newly discovered genus to Lt. Doutt in appreciation of his efforts to gather specimens of scientific value in spite of his preoccupation.

## *Douttia*, new genus

Body *Trigonopterus*-like in form; mostly bare above, but with patches of squamae.

Head with crown exposed from above; interocular area narrowing dorsad, narrowest part narrower than base of rostrum; eyes large, coarsely faceted, subcontinuous in outline with head. Rostrum approximately as long as pronotum, arcuate, depressed, comparatively slender; mandibles bidentate; scrobes lateral and concealed from above; antennae inserted behind middle in both sexes. Antennae with scape reaching base of rostrum, shorter than funiculus excluding club; funiculus 7-segmented, first two segments elongate and subequal, segments 3 to 7 successively shorter and more transverse; club ovate, about one half as long as funiculus, shorter than scape.

Prothorax subconical, transverse; base subtruncate; postocular lobes obtuse. Scutellum minute. Elytra subcontinuous in lateral outline with prothorax; humeri not prominent; base sinuate; ten striae; intervals broad. Wings reduced or aborted.

Legs with femora not or but slightly clavate, partly, shallowly and obscurely grooved beneath, not toothed, extending to or slightly beyond apex of elytra; tibiae angulate at base, otherwise almost straight, not multicarinate, terminal uncus well developed, but without a tooth at inner apical angle; tarsi with segment 1 elongate, longer than 2, 2 about as long as 3, 3 very broad, deeply bilobed, 4 projecting well beyond apex of 3; claws well developed, stout, divaricate.

Sternum with prosternum much longer in front of coxae than length of a fore coxa; pectoral canal deep, bare, terminating between mesocoxae; mesosternal receptacle broadly open behind, side walls high and strongly developed, hind wall absent; metasternum much shorter at its narrowest point between mid and hind coxae than the

longitudinal chord of a mesocoxa; metasternal episterna narrow; metacoxae almost reaching elytra.

Abdomen with ventrite 1 longer than 2, longer than length of metasternum along median line, intercoxal process broadly arcuate or broadly sub- $\Delta$ -shaped, without carinae or striae, on a lower plane than ventrite 2; suture between ventrites 1 and 2 coarse and distinct throughout; ventrite 2 longer than 3 or longer than 3 plus 4 which are subequal in length and together are shorter than 5.

Genotype: *Douttia bicolor*, new species.

Without detailed examination, the genotype appears to belong to *Trigonopterus* Fauvel. It has the same general form, color pattern, and facies of a number of species of that large and widespread genus. However, the open mesosternal receptacle alone immediately will separate the two genera. Moreover, in addition to the character differences of the mesosternal receptacle, there are many other morphological features of *Douttia* which are quite distinct from those of *Trigonopterus*. In typical *Trigonopterus* neither the scutellum nor the metepisterna are visible, the femora are deeply and conspicuously sulcate beneath, the tibiae are usually conspicuously multicarinate, the tarsal claws are minute and the rostrum is much stouter than in *Douttia*.

In Lea's key to the Australian genera allied to *Trigonopterus* (*Idotasia*) (Trans. Royal Soc. South Australia, 52 : 154, 1928), *Douttia* will run to *Leucomelacis* Lea, 1928. *Leucomelacis* has the sutures of the second to fourth ventrites "drawn backwards at the sides," an aberrant character which alone will serve to separate the two genera.

It is to be anticipated that a number of new species of this genus will be discovered when the Melanesian islands are adequately explored.

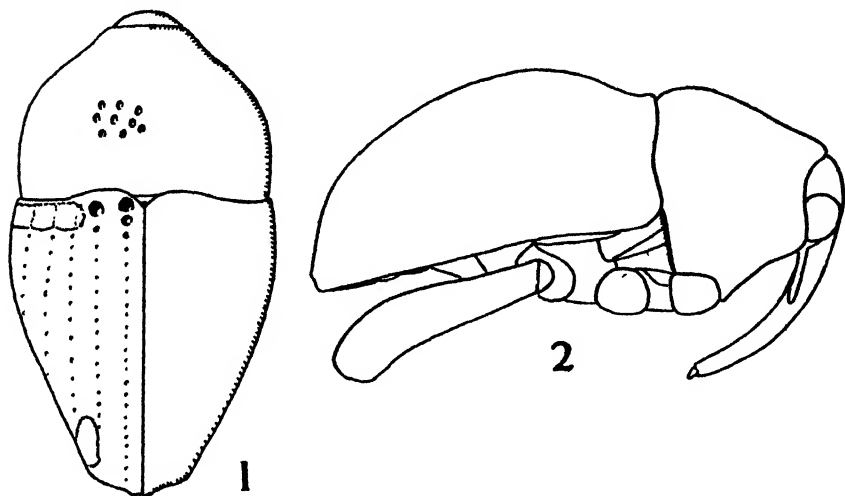
### ***Douttia bicolor*, new species**

Figures 1 and 2

*Color*.—Derm dark wine-red to black, variable, dorsum shiny; scales on head mostly brown, but with a conspicuous white patch along median line which is about as broad as interocular area at top of eyes but which narrows toward pronotum; pronotum without squamose patches; each elytron with a conspicuous basal band of dense, snow-white scales extending across intervals 4 to 9 inclusive with a few scales extending on to outer edge of interval 3, greatest cephalic-caudal length of the band almost as great as breadth of intervals 4 plus 5, and each elytron with a conspicuous elongate patch of similar scales subapically situated on declivity, mostly on interval 3 but occupying the shallow concavity between terminations of striae 2 to 8, this vitta separated by about one half its length from apex of elytron, about as long as distance across first three or four striae at basal margin of elytron, and about three times as long as its breadth; legs with femora conspicuously clothed along dorsal edge for one third to one half distal length with dense, ovate, snow-white squamae, elsewhere with less conspicuous, more scattered brown scales or with additional white squamae along lower edges, especially toward base; tibiae with brown and white scales, white scales predominating internally and usually apically on outer edge; scales and setae of ventral surfaces white.

**Head.**—Crown evenly convex, but slightly flattened or depressed at position of the vague median fovea; interocular area gradually narrowed from base of rostrum to tops of eyes, and there more than two-thirds as broad as base of rostrum; crown densely clothed with ovate, appressed scales which conceal the shallowly punctate, coarsely reticulate derm, all scales directed forward excepting the anterior ones in the white vitta which are directed backward; interocular area sparsely squamose, with most of the scales along sides.

**Rostrum.**—The chord measured from lower cephalic corner to lower apex as long as a fore tibia including uncus in male, one sixth longer than a tibia in female; gradually and slightly narrowed from base to insertion of antennae, thence gradually and slightly widened



FIGURES 1 and 2. *Doultia bicolor*, new genus and species, outline diagrams of dorsal (fig. 1) and lateral (fig. 2) aspects to show principal features (female).

to apex, apex very little broader than breadth at antennae; antennal insertion at basal two-fifths in male and at basal one-third in female; with a sulcus and carina above each scrobe, but otherwise not sulcate nor carinate; male with post antennal area comparatively coarsely punctate, punctures longitudinally confluent or subconfluent, area beyond antennae densely set with smaller punctures; female with postantennal area less coarsely punctured, and with minute punctures beyond antennae.

**Antennae.**—Scape clavate, sinuous, sparsely setose, as long as first four funicular segments or slightly longer, at its broadest point about equal in breadth to first funicular segment; funiculus with first two segments subequal in length, but 1 about one-third broader than 2, 2 slightly longer than 3 plus 4, segments 3 to 7 successively broader, 7 about one-third broader than long and approximately as broad as 1; club ovoid, not quite as long as five preceding segments combined.

*Prothorax*.—Proportions in male allotype 34 units wide and 26 long and in female holotype 36 units wide and 27 long; broadest behind middle, broadly rounded on sides from base to near apex and there distinctly constricted, the constriction hardly interrupting longitudinal dorsal outline; longitudinal dorsal contour most strongly convex at base, and there rising distinctly above base of elytra; disk bearing medium-sized, round or oval punctures, well separated caudad, but more numerous and more closely placed cephalad, and larger, coarser and closer on pleura, becoming longitudinally confluent or subconfluent along pectoral canal and on postocular lobes, each puncture bearing a short inconspicuous seta; scales absent; hind margin at most shallowly and indistinctly sinuous, slightly overlapped by bases of elytra, coarsely and closely punctured, with the coarsely punctate area broadest and most coarsely sculptured in front of scutellum.

*Scutellum*.—Punctiform, inconspicuous.

*Elytra*.—Base distinctly sinuous, not broader than base of prothorax, broadly arcuate on sides to the broadly rounded, sub-truncate apices, broadest a short distance behind humeri and there about equal in breadth to greatest breadth of pronotum, about seven-tenths as broad as long and about twice as long as length of pronotum; longitudinal dorsal contour conspicuously discontinuous with that of pronotum, depressed at base for about one-half breadth of the squamose fascia, then rising to reach its highest point before middle and there on a higher plane than pronotum, thence continuing in a broad curve to apex; squamae in basal and subapical patches dense, imbricated; scaling in basal patch not continued to absolute base and striae appearing as narrow lines through scaling; striae 9 and 10 impressed to apex, but other striae obsolete or nearly so excepting at base and apex and marked only by inconspicuous or small punctures smaller and shallower than those on pronotum on disk, but each marked by large, coarse, deep punctures at base, the large punctures successively more numerous in outer striae, elytral disks appearing smooth, without any striae and interval irregularities; setae hardly discernible except at apex and short there; interval 1 slightly elevated and stria 1 depressed at apex.

*Legs*.—Femora closely punctate, not dentate, but with anterior edge of fore pair rather coarsely sculptured and somewhat minutely irregular and with or without a minute denticle; anterior femora with long, white, hair-like setae on ventral edge in male only; greatest width of hind femora divided into length equals about 3.05; tibiae arched at base, thence almost straight, uncus arising from outer apical angle and well developed, without any carinae, lower edge with more numerous longer setae; dorsal parts of tarsi clothed with white setae, under surfaces densely setose; hind tarsus with segment 1 as long as 2 plus 3, 2 as long as and one-half as broad as 3, 3 deeply bilobed, each lobe about as broad as 2, segment 4 arising near base of 3 and as long as breadth of 3, claws about as long as basal breadth of segment 3.

*Sternum*.—Fore margin of prosternum deeply concave at the deep pectoral canal, side margins of canal in front of coxae about

one-fourth longer than length of a fore coxal cavity, distance between a coxa and hind margin of prosternum less than one-third length of a fore coxa, intercoxal distance one-third length of a fore coxa; fore coxae with a patch of white, erect or suberect setae and squamiform setae at distal, inner, hind corner; mesosternal receptacle with side walls sloping upward and backward to level of metasternum, fore edges touching fore coxae and there on about same level as squamose patch on fore coxae (this condition is evident only when the prothorax is drawn against the after body in its natural position of rest), lower edges densely clothed with long, bristly, erect, coarse, hair-like setae in male and with erect mostly squamiform setae and with a few fine scattered setae in female; mesocoxae with large, conspicuous, ovate squamae; metasternum deeply concave in both sexes, hind margin deeply concave, the length along median line only about one-half length of ventrite 1, clothed with ovate squamae, which are more numerous toward sides and with slender, very narrowly lanceolate, slanting setae in female, but densely clothed with long, shaggy white hair in male and with ovate squamae on sides in both sexes; side pieces of meso- and metasternum squamose.

*Abdomen*.—Of female: ventrite 1 about as long as 2 plus 3, convex, with large closely placed punctures bearing fine reclinate setae and with a few ovate squamae near coxae and along hind margin; ventrite 2 shiny, slightly longer than 3 plus 4, slanting conspicuously downward and forward, with small punctures bearing fine setae and with a single or partially double row of large ovate squamae along posterior margin; ventrites 3 and 4 subequal in length and together about as long as 5, arrangement of vestiture similar to that on 2, punctures inconspicuous; ventrite 5 closely punctate, with reclinate setae and a few squamae. Abdomen of male: ventrite 1 almost as long as 2 plus 3 plus 4, with the disk deeply and broadly concave, the concave area densely clothed with very long, shaggy, white hair, but the sides squamose; ventrite 2 about as long as 3 plus 4, coarsely sculptured, coarsely alutaceous, with scattered setae and with both fore and hind margins squamose; ventrites 3 and 4 with about their posterior halves conspicuously squamose; ventrite 5 densely punctate, setose on disk and squamose at base and on sides.

Length: 3.5–3.75 mm. (excluding head); breadth: 1.75–1.9 mm.

*Types*.—Holotype female and allotype male collected by Lt. R. L. Doutt on Espiritu Santo Island, New Hebrides, September 19, 1942, and deposited in Bishop Museum, Honolulu, T. H.

I have designated the female as holotype because the male has lost the left antenna and the left postocular lobe is deformed (it is notched instead of being convex). The male is almost entirely black, whereas the female has the prothorax and elytra largely dark wine-red. The contrast between the snow-white squamose patches and the black or reddish background forms a pleasing color combination.



# THE RELATIONSHIP OF *DASYMUTILLA PERMISTA* MICKEL TO *DASYMUTILLA QUADRIGUTTATA* (SAY) AND BEHAVIOR NOTES ON THE SPECIES

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A problem frequently encountered in the family Mutillidae is the correct correlation of males and females of a species. The great dissimilarity of the sexes of members of this family makes it frequently impossible to connect males and females by study of preserved specimens alone. Biological observations are necessary to establish conspecific identity of males and females. Three types of observations appear to best show the correlation of males and females: (a) copulating pairs are almost certainly of the same species; (b) males and females reared from the same host are probably conspecific; (c) numerous identical males and identical females in the same area simultaneously may be suspected to be of one species. The evidence which follows proves through all three methods that *Dasymutilla permista* Mickel is the male, and thus a synonym, of *Dasymutilla quadriguttata* (Say).

In his study of the genus *Dasymutilla* Ashmead, Mickel<sup>2</sup> discussed the possible relationship of *D. quadriguttata* (Say), known in the female sex only, and *D. permista* Mickel, known only from males. He pointed out that since Hayes had reared both species from cocoons of *Elis quinquecincta* Fabricius the two might possibly be conspecific, but this seemed improbable because *permista* occurs not only in the same area as *quadriguttata* but also much farther eastward. It is possible that *D. interrupta* Banks is a geographic race of female *D. quadriguttata*, replacing the latter east of Minnesota, Illinois, and Mississippi. This problem needs study.

On July 2, 1943, the writer was surprised to find great numbers of male mutillids coursing back and forth over a large grass lawn situated among heavily wooded hills on the eastern bank of the Mississippi River. No mutillids had been seen there previously, although the writer had crossed the place while searching for insects on each of the several preceding days. About thirty-five were caught in twenty minutes, as many as three being taken in single sweeps of the net. With a sufficient amount of collection material, the writer then began watching the actions of the handsome wasps.

<sup>1</sup>Thanks are due Dr. C. E. Mickel for verifying the identification of the pair seen to mate and the other males and females taken at the same place. The pair seen in coitus and additional males and a female have been placed in Dr. Mickel's extensive collection of Mutillidae.

Dr. H. K. Townes kindly verified the identification of the *Myzine quinquecincta* (Fabricius).

<sup>2</sup>Mickel, Clarence E. 1928. Biological and taxonomic investigations on the mutillid wasps. U. S. Nat. Mus. Bull. 143.

Each of the several hundred males visible was slowly and irregularly flying over the lawn less than six inches above the recently-cut grass. Every few minutes the wasps would alight and begin crawling through the grass, taking wing again in about thirty seconds. Several individuals were followed for five to ten minutes each, and on no occasion did a male find the object of his search (presumably a female). On July 5 a female was followed for twenty-five minutes, during which period it moved steadily through the grass. It was exposed to full view more than half the time, but no males discovered it during the period of observation. Several males flew within three inches of the moving and conspicuously-marked female, and others actually crawled through the grass within four inches of her, without discovering her. Some showed apparent excitement on crossing a spot where the female had just passed, but their searching was aimless and fruitless.

On July 2, after no copulating pairs could be found, the writer placed a male (*permista*) in a glass bottle with a female (*quadriguttata*). The male attempted to escape for about a minute, and then discovered the female. He immediately lit on her back and went into coitus with her. After approximately three seconds of copulation, he flew up, and evidenced no further interest in her. This behavior definitely indicates that *D. permista* and *D. quadriguttata* are the same species.

In the observations carried on between July 2 and 5, only a few lone individuals of these mutillids were seen beyond the edges of the lawn. In addition, no other species of mutillids were observed on the lawn during that period. Several hundred males were observed, and industrious searching yielded four females. The difficulty in finding the latter was because their winglessness confined them to the ground, where the grass easily concealed them.

It was of interest to note that both males and females made a high-pitched squeaking noise when captured. Mickel has shown that this sound is produced by rubbing the third abdominal tergite against the underside of the second tergite. In all cases observed by the writer this sound appeared to be made in protest rather than as a signal, as none of the free individuals nearby seemed attracted to the captive sound-producing wasps. Free males and free females were never heard to make these sounds. No difference was perceived between the noises made by males and by females.

An effort was made to find indications of the host or hosts of *D. quadriguttata*. Only one other wasp was present on the lawn in conspicuous numbers, *Myzine (Elis) quinquecincta* (Fabricius). These wasps were nearly as numerous as the mutillids, and pairs of *M. quinquecincta* were twice seen to copulate. In the light of Hayes' findings and the above observations, it seems safe to suppose that *M. quinquecincta* is the host of *D. quadriguttata* on the campus of Principia College near Elsah, Jersey County, Illinois, where these studies were made. The writer's entrance into the Army necessitated discontinuance of these investigations.

#### SUMMARY

A male *Dasymutilla permista* Mickel was seen to mate with a female *Dasymutilla quadriguttata* (Say). These therefore represent one species.

*Quadriguttata*, being the older name, must stand, and *permista* falls under it as a synonym.

Certain observations of the habits of this species are set forth: (1) Hundreds of males were seen flying over the limited area covered by a large, close-cut lawn. Their interest seemed to be in finding females. (2) These males seemed remarkably unsuccessful in discovering females, even when passing within a few inches of an active and conspicuous female. (3) Coitus lasts only a few seconds with this species. (4) Both sexes make a high-pitched squeaking when caught. This sound appears to be a manifestation of fear or annoyance, and not a signal; free wasps showed no response to loudly squeaking captives. (5) The great abundance of *Myzine quinquecincta* (Fabricius) on the lawn with the mutillids, coupled with Hayes' rearing of *D. quadriguttata* from *M. quinquecincta* cocoons, leads the writer to believe that the tiphiid is the host of the mutillid where the above investigations were made.

THE ORGANIZATION OF PERMANENT NATION-WIDE ANTI-AEDES AEGYPTI MEASURES IN BRAZIL, by FRED L. SOPER, D. BRUCE WILSON, SERVULO LIMA, and WALDEMAR SA ANTUNES. 137 pages, 27 figures. The Rockefeller Foundation, 49 W. 49th Street, New York 20.

The history of yellow fever is not a closed chapter. Frequently we are guilty of thinking too often in terms of the past and failing to recognize what contemporary students are doing. Knowledge of yellow fever has increased greatly since 1925. An outstanding discovery, in recent years, was that the disease occurs as one of jungle animals, independent of man and *Aedes aegypti*, in many South American countries.

Outbreaks of yellow fever in cities is believed due largely to invasion by the virus from the jungle. When cities have *Aedes aegypti* there is opportunity for a serious epidemic following introduction of the virus.

Anti-*aegypti* campaigns in Brazil aimed at the reduction of the species in cities have been discarded for a strategy of eradication of this mosquito from the entire country. This daring program, fostered in large part by the International Health Division of the Rockefeller Foundation, is now under the control and at the expense of the Brazilian government.

Briefly stated, the program consists of an initial clean-up campaign followed by elimination of those few places responsible for maintaining the species, and the maintenance of an organization to prevent reinfestation or to cope with the problem in case reinfestation occurs.

The methods of combat used by the Yellow Fever Service are thoroughly described but since they are well known, at least in their major aspects, to all entomologists acquainted with the practice and literature of mosquito control, they will not be discussed here. The organization and administration of the program are elaborately described and form the major portion of the book. The success of the Brazilian project is largely due to proper use of an elaborate system of maps and reports which are filled out by every worker. Also important in success is the expenditure of approximately 25 per cent of the labor budget in checking all work done.

This book is nicely printed and bound and it has an index. It has a limited distribution free of charge to doctors and public health officials.—VENARD.

# ANTHROPOMORPHISM IN INSECT PSYCHOLOGY

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Students of comparative psychology know, or are soon made aware, that in the description of the behavior of animals the use of the familiar terms of man's mental activity is taboo. This attitude has become so general that writers, with few exceptions, take pains to cleanse their vocabulary of all such terms, lest they suffer the embarrassment of having their utterances called anthropomorphic. The word, originally borrowed from another field of interest, has grown not merely to have a technical meaning, but also to carry a connotation, an implication and an emotional atmosphere that is haughtily derogatory. Now, since a generation of young men have come to maturity in this atmosphere, it is quite natural that they should unthinkingly accept and share much of this attitude. Before continuing this course further, is it not fitting that we should pause and consider the validity of its claims?

Anthropomorphism, strictly speaking, means the endowing of a god with the form or attributes of man. The word has been slightly revamped to fill a need in scientific parlance. The meaning of the word, according to Darbishire<sup>1</sup> has been enlarged at both ends. It has been extended at the human end to the endowing of a god with attributes "which are more essentially human than the mere shape of man—namely, the way in which a man does things, and the kind of things he does." It has also been enlarged at the "endowed" end so as to mean the endowing of anything, usually some non-human living thing, with anything human. The extension of the word at this end came about during the nineteenth century, *pari passu* with a growth of a disbelief in God, especially among men of science. There was no god for them to endow with human attributes. It was a pity that a good long word like anthropomorphism should be wasted. So it was used to mean the endowing of anything non-human with any human attribute. You must not say that the lark sings for sheer joy, because that is an anthropomorphic interpretation of the song of the lark. Any ascription of purpose or intention, intelligence or design, to a non-human animal is condemned at once by contemporary orthodox biologists on the ground of its radical anthropomorphism.

There are apparently two schools that object to the use of anthropomorphic language in the study and interpretation of animal behavior: (1) those who wish to reserve purpose, intention, intelligence and design as attributes of man only, because the granting of the so-called human attributes to the infra-humans is repugnant to them; (2) those who "liked to think of the organism as a machine, and they liked their mechanical theory of evolution. . . . The belief that a non-human animal has an intelligence at all comparable to their own was branded

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<sup>1</sup>An Introduction to a Biology, pp. 79-80, 1917.

with the word anthropomorphic and flung into the dust-bin of exploded superstitions."

The first school may be quickly answered by saying with Darbishire, "It is true that purpose, intention, intelligence and design are attributes of man. It does not follow from this that they are attributes of man *only*."

The attitude of the second school may be briefly summarized by quoting Forel<sup>2</sup> who refers to the works of "Bethe, Beer, Uexküll and Loeb, among others, who, in the name of the exact sciences, have disputed the possibility of a comparative psychology. In their opinion, everything must begin again; we have so far been only anthropomorphic. We have not any right to admit either sensations, perceptions or memories in animals. . . . It is necessary to remodel all the nomenclature, which is rotten with anthropomorphism. One will no longer be able to speak of vision, nor of smell, etc., among the beasts, but only of photo-reflex or chemoreflex. The odour of the nest will be the substance of the nest; the combined individual, family and regional odour of the nest of bees will be consequently the substance of the individuo-regino-familio-nido-chemical reflex. What we have thought we have recognised as memories and associations will be the unknown forces A, B, C, D, etc."

Forel himself seeks the golden middle way, for in the preface of the same book we find him saying, "The whole question is, therefore, a chapter of comparative psychology, a chapter in which it is necessary to take careful note of every factor, to place oneself, so to say, on the level with the mind of an insect, and above all to avoid 'anthropocentric' errors with which works upon the subject are filled. At the same time, the other extreme must be equally avoided—'anthropophobia,' which at all costs desires to see in every living organism a 'machine,' forgetting that a 'machine' which lives, that is to say, which grows, takes nourishment, and strikes a balance between income and expenditure, which, in a word, continually reconstructs itself, is not a machine, but something entirely different. . . . In other words, we must steer clear of two dangers. We must avoid (1) identifying the insect mind with our own, and above all (2) imagining that we with what knowledge we possess, can reconstruct the mind by our chemical and physical laws."

Other students besides Forel who took exception to this pedantic attitude were Reaumur, Fabre, the Peckhams, Lubbock, Sladen, Rayment, McCook, Plath, and Frison. Outstanding among them is the late William Morton Wheeler, who often reported his findings in ant behavior in anthropomorphic language; he knew he was doing so, and on several occasions defended his attitude. In explaining his position in one place, he ironically acknowledged having committed "the eighth mortal sin." One can easily picture Wheeler smiling a quiet, private smile when he wrote that sentence, for the dictionary tells us that a mortal sin is a serious sin, aggravated by circumstances, and committed deliberately with the full consent of the will. Wheeler on other occa-

<sup>2</sup>The Senses of Insects. Tr. by M. Yearsley, p. 271, 1908.

sions sought to enlighten the critics of anthropomorphic usage who pedantically clung to the epithet evidently without fully knowing the history of the word. He wrote with logic and satire, but evidently without deep effect, for even today, after a lapse of twenty-five years, the literature of insect behavior still has a cramped style of expression because authors struggle to side-step the discredited type of expression in their writings, and editors continue to frown upon even minor anthropomorphisms in manuscripts.

Of course, it is readily admitted, an enthusiastic writer stands in danger of bringing into the recording of the behavior of his insects and animals exaggerated notions of their abilities. We hold no brief for such. On the other hand, it should be to the credit of the narrator if he circumvents boredom by relaxing into easy, forthright statements of his observations. It is indeed stupid for a writer to be required to qualify every phrase with an "I think," "it seems to me," or "to my mind." If a writer says "a bee chooses," "an ant decides" or "a wasp wishes," we should assume that he could have said, if he were sufficiently pedantic, "the bee behaves as if it chooses," "the ant acts as if it decided," and "the wasp performs as though it wished." Qualifications such as these make the writer all things to all men, and whatever the reader's turn of mind the writer will never be accused of placing the animal in the same psychic category with man. But in saving one's face one may hold back the fullest interpretation of animal behavior. In fact, one may thus help to perpetuate the mischief created by C. Lloyd Morgan in what is called Morgan's Canon or Morgan's Law of Parsimony, which, briefly summarized, holds that no act should be ascribed to a higher mental faculty if it can be accounted for in terms of a lower one.

It is quite clear that I am voicing a protest against the limitations which the mechanistic attitude imposes upon discussions of comparative psychology. Let me make it equally clear that I freely grant to the physiologists and to certain schools of the psychologists their own technical interpretation of the activities of the organism. Let them hold to the conclusion, if they will, that ultimately thought is a manifestation of chemical phenomena, and that physical bodies are resolved into terms of electrons responding to the influence of certain forces, etc.; let them build up a new vocabulary to express that concept for use in their own field. But let them keep the steam in their own boilers and avoid the error of trying to enforce the use of this highly specialized vocabulary in other fields. Let them grant to the observer of living, changing, struggling, exuberant creatures a vocabulary adequate to describe what he sees. The truth of one aspect of an organism does not cancel out the truth of another aspect of it, any more than an artist's interpretation of paints renders untrue the chemist's conception of the same paints. We can never hope to explain the *bios* of biology by establishing Blue-Laws about the language in which we speak of its wonders and mysteries. The mere replacing of old terms with new ones reveals only the observer, but throws no new light on the observed. Having summarily flung the thing out the door, we make haste to drag it back in through the window.

The loudest howlers against the use of anthropomorphic language in behavior studies are not the field naturalists, who study the organism in all its natural relations, but the physiologists, and the laboratory investigators, who keep their frantic quarry in miniature concentration camps in the laboratory, or as specimens steeped in alcohol. These latter men Goethe knew well a hundred years ago when he made his brilliant devil say:

"He that would study and portray  
A living creature, thinks it fit  
To start with finding out the way  
To drive the spirit out of it.  
This done, he holds within his hand  
The pieces to be named and stated,  
But ah! the spirit-tie that spanned  
And knit them, has evaporated.  
This process, chemic science pleases  
To call *Naturae Encheiresis*,  
And in the very doing so, it  
Makes of itself a mock, and does not know it."

Studies and interpretations of animal behavior have not made greater progress because we have had too few Goethes and Wheelers to rebel against the domination of *biology* by the methods of physics and chemistry.

But Wheeler knew the strength of his position and he defends with valor the "writings tinged with anthropomorphism." Some of his remarks are indeed worth repeating for the benefit of students, and by reprinting them here we will bring them out of the oblivion of obscure places of publication. I beg leave to close with the following quotations.

In his book on *The Social Insects* (p. 3), Wheeler says, "The anthropomorphism attaching to the word 'social' is easily explained and may be condemned or condoned according to the general philosophical convictions of the critic. I can only record my belief that in the discussion of matters psychological, we can scarcely avoid a certain amount of anthropomorphism or teleology."

He has some interesting things to say on this matter when he reviews the book by Sladen on the Humble-Bee (*Science*, N. S. 37: 180-182, 1913). He comments on the fact that Sladen does not refer to the work of Wladimir Wagner on the same insects with the sonorous title of "*Psychologische Untersuchungen Hummeln mit Bezugnahme auf die Frage der Geselligkeit im Tierreiche*," and mischievously adds, "one familiar with this work may be pardoned if he secretly hopes that Sladen has never seen it, not because it is devoid of considerable merit, but because its spirit gives one reason to suspect that Sladen might have become sophisticated by its perusal. . . . In Sladen's work, the Humble-bee is the heroine of the story. She moves before us in all the glory of her regal velvety attire, with the joyous or apprehensive hum of incessant, arduous labor and self-sacrificing motherhood. In Wagner's account it is Wladimir Wagner who occupies the foreground as the

somewhat bumptious scientist who looks at the bumble-bee and makes an observation, forthwith settles its connection with some lop-sided hypotheses, incidentally belabors a few contrary-minded students of animal behavior. . . . Sladen on the other hand writes with charming insight and utterly unmindful of committing one of the most deadly sins that it is possible for a modern student of animal behavior to commit, pens such sentences as the following: 'The queen's *intelligence* is seen at its best while she is thus *caring* for her brood, and the *devotion* to it and her *alertness* on the slightest approach to danger are most interesting to witness. She shows no *desire* to escape unless she is severely molested and is quite *content* with her brood, *anxiously* incubating it day and night'." (Italics Wheeler's). And then by way of contrast, Wheeler quotes at length from Wagner's pompous story of the humble-bee, prefacing this quotation with: "This is the way Wagner, who is beset with the terrible anxiety lest he commit this deadly sin of 'grober Anthropomorphismus' describes the behavior."

Wheeler concludes with these enlightening remarks: "Such quotations reveal the differences between the two schools of animal behavior which they represent. To one the insect is a wonderful and inexhaustible living organism, whose activities can be most satisfactorily described in the language which we employ when speaking of another individual of our own species; to the other the insect is a pure mechanism whose every movement is easily expounded by the observer, who stands in the foreground and uses the observed object largely as a means of displaying his own analytical and explanatory acumen."

In his work *On Instincts*,<sup>3</sup> he comments as follows: The anthropomorphic view of instinct is "essentially a recognition of the fundamental identity of the animal and human soul, the differences between which are regarded merely as differences of degree of development. This implies that intelligence is not exclusively human and that the animal mind is to be interpreted in the light of human psychology, a procedure which is, of course, open to the charge of anthropomorphism. But owing to the fact that all our science is necessarily anthropomorphic and that man himself is merely a highly developed animal and therefore could not if he would interpret other animals except in terms of himself, the charge can only mean that he continually runs the risk of attributing to animals a greater development of intelligence than they possess. As scientific methods of observation and experiment are quite adequate for the control and rectification of this tendency, it is impossible to regard anthropomorphism as such a very terrible eighth mortal sin."

Apparently also everything is not quite kosher in the camp of students of human psychology in respect to this matter of anthropomorphism, and the remarks by Dr. D. B. Klein in an article entitled "Scientific Understanding in Psychology"<sup>4</sup> may serve as underpinning for the views of both Wheeler and Darbishire. ". . . the psychologist made a tactical blunder in his efforts to place the study of mental phenomena on a scientific basis. He followed the pattern of the natural

<sup>3</sup>Essays in Philosophical Biology, pp. 47-48, 1939.

<sup>4</sup>Psychological Review, 39: 552-569, 1932.



sciences too slavishly. He seems to have reasoned that since it was necessary for these sciences to purge themselves of all vestiges of anthropomorphism, his science must do the same, and although it may sound heretical, we feel constrained to say that this is precisely what he should not have done. He alone was justified in making his science anthropomorphic. To argue that the study of human nature must be devoid of anthropomorphic interpretation is akin to urging the chemist to steer clear of chemical interpretations. . . . To be scientific, psychology must become more anthropomorphic, not less so, paradoxical and tautological as this may sound."

It logically follows that, if anthropomorphic interpretation is necessary for the study of human behavior, it is also necessary for the study of the other animals; and as undercurrents of dissatisfaction such as Klein's come more and more to the surface, students will know that if Wheeler sinned in the pioneering for a place for anthropomorphism in the literature of animal behavior,

"Some rise by sin, and some by virtue fall."

—*Shakespeare.*

ANOPHELES GAMBIAE IN BRAZIL 1930-1940, by FRED L. SOPER and D. BRUCE WILSON. xviii+262 pages, 49 tables, 5 plates, 75 figures. The Rockefeller Foundation, 49 W. 49th Street, New York 20.

The fight in Brazil against *Anopheles gambiae* has received widespread publicity and, therefore, this complete account of the battle will be eagerly read by entomologists. It will be particularly valuable to medical entomologists and to those individuals interested in the theory and practice of species eradication of insect pests.

The nature of the book is well illustrated by the titles in the table of contents which are: Introduction; The Invader; Description of *Anopheles gambiae*; The Region Invaded; Early Results of *gambiae* Invasion; The Silent Era, 1932 to 1937; Invasion of More Favorable Regions; Epidemic malaria in the Northeast; Surveys and Control Measures; The Malaria Service in the Northeast; Spread and Retreat of *gambiae*, 1937 to 1940; Spread and Recession of Malaria, 1939 to 1941, in *gambiae* Infested Region; Statistical Summary of the Malaria Service of the Northeast; Special Sections; Discussion; Summary; Appendix I; Appendix II; Appendix III; Bibliography, and Index.

Dr. Raymond B. Fosdick has recently reported (The Rockefeller Foundation. A Review for 1943) that *anopheles gambiae* is again in Brazil. This information will give fuel for discussions as to whether the mosquito was eradicated. The evidence that the mosquito was eliminated is convincing and although\*it was originally introduced to Brazil from Natal by a fast destroyer it has been found on airplanes several times and in this way there has been opportunity for reinfestation.

There is no reason to assume that this mosquito could not live in our Gulf States and due to our air service with Africa we should be on the alert for the introduction of *A. gambiae*. Additional reasons for becoming familiar with the contents of this book are that it is a thrilling account of an important chapter in the history of a man's fight against malaria and the methods used in eliminating *A. gambiae* are given in detail.

There is no charge for this book and its distribution is to doctors and public health officials.—VENARD.

# THE FLEAS (SIPHONAPTERA) OF ALBERTA, WITH A LIST OF THE KNOWN VECTORS OF SYLVATIC PLAGUE

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and

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Sylvatic plague, the type of bubonic plague that occurs in rural areas, has been demonstrated to be present in Central Alberta. It mainly affects rodents but can be readily transmitted to man, to whom it is usually fatal. The Alberta Sylvatic Plague Survey, organized in the spring of 1938 under the auspices of the Alberta Department of Public Health, has been shooting and trapping small rodents in Alberta, and examining them for the presence of plague lesions; the fleas present on these rodents have also been collected, and examined for the possible presence of plague.

The following list of Alberta Siphonaptera has been compiled from records published by Rothschild and Jordan, and from named material in the University of Alberta collection. All of the specimens in the University collection were collected by the author during the course of the Alberta Sylvatic Plague Survey.

In listing the species particular attention has been paid to recording hosts and distribution, so that a comprehensive picture of the flea situation in Alberta might be obtained. As the order Siphonaptera is in a state of chaos, the species in Alberta have been listed under the names recorded by Ewing and Fox (2) and by Jellison and Good (3). Specimens in the University of Alberta collection are designated by (1). The names preceded by an asterisk (\*) are the names under which the species were previously reported from Alberta.

The plague vectors together with their hosts, as recorded by Eskey and Haas (6) and known to be present in Alberta, are listed separately. (See numbered references at end of article.)

## LIST OF THE SIPHONAPTERA OF ALBERTA

1. *Amphalius necopinus* (Jordan), 1925, (2, 5).  
Host.—Pika or rock-rabbit (*Ochotona princeps*).  
Locality.—Banff.
2. *Amphipsylla sibirica pollionis* (Roths.), 1905, (2, 3).  
\**Ceratophyllus pollionis* Roths., by Rothschild in 1903, (3).  
Hosts.—Meadow mouse (*Microtus drummondi*), red-backed mouse (*Eutamias gapperi saturatus*).  
Locality.—Red Deer.
3. *Arctopsylla ursi* (Roths.), 1902, (2).  
\**Pulex ursi* Roths., by Rothschild in 1902, (3).  
Host.—Grizzly bear (*Ursus horribilis*).  
Locality.—West of Calgary.
4. *Catallagia borealis* Ewing, 1929, (2, 4).  
Host.—Short-tailed shrew (*Blarina brevicauda*).  
Locality.—Alberta.

5. *Catallagia charlottensis* (Baker), 1898, (2).  
*\*Ceratophyllus charlottensis* (Baker), by Rothschild in 1905, (3).  
*Hosts*.—White-footed deer mouse (*Peromyscus leucopus*), wood rat (*Neotoma cinerea*), red-backed mouse (*Eutamias gapperi saturatus*).  
*Locality*.—Alberta.
6. *Catallagia decipiens* Roths., 1915, (2, 3).  
*Hosts*.—Red-backed mouse (*Eutamias gapperi saturatus*), Columbian ground squirrel (*Citellus columbianus*).  
*Localities*.—Red Deer, Blackfalds.
7. *Cediopsylla inaequalis inaequalis* (Baker), 1895, (1).  
*Cediopsylla (Acediopsylla) inaequalis inaequalis* (Baker), (2).  
*Host*.—Jack-rabbit (*Lepus*, sp.).  
*Locality*.—Orion.
8. *Ceratophyllus garei* Roths., 1902, (2, 3).  
*\*Ceratophyllus garei* Roths., by Jordan and Rothschild, 1920.  
*\*Ceratophyllus garei* Roths., by Jordan 1929.  
*Hosts*.—Geese (Anserinae), white-winged scoter (*Melanitta deglandi*), and other avian hosts.  
*Locality*.—Edmonton.
9. *Ceratophyllus niger* C. Fox, 1908, (2).  
*Ceratophyllus niger niger* Fox, 1908, (3).  
*\*Ceratophyllus niger niger* Fox, by Jordan, 1929.  
*Hosts*.—Turkey (*Meleagris gallopavo*), domestic fowl (*Gallus domesticus*).  
*Locality*.—Alberta.
10. *Corrodopsylla curvata curvata* (Roths.), 1936, (2, 3).  
*\*Doratopsylla curvata curvata* Roths., by Rothschild, 1915.  
*Hosts*.—Kangaroo mouse (*Zapus hudsonius*), shrew (*Sorex* sp.).  
*Locality*.—Blackfalds.
11. *Ctenocephalides canis* (Curtis), 1826, (1, 2, 3).  
*Hosts*.—Cat (*Felis catus*), dog (*Canis familiaris*).  
*Locality*.—Edmonton.
12. *Ctenocephalides felis felis* (Bouché), 1835, (2, 3, 1).  
*Host*.—Cat (*Felis catus*).  
*Locality*.—Edmonton.
13. *Ctenophthalmus pseudagyrtus* Baker, 1904, (2, 3).  
*\*Ctenophthalmus pseudagyrtus* Baker, by Rothschild, 1904.  
*Hosts*.—Meadow mouse (*Microtus drummondi*), red-backed mouse (*Eutamias gapperi saturatus*).  
*Locality*.—Red Deer.
14. *Ctenophyllus terribilis* (Roths.), 1903, (2, 3).  
*\*Ceratophyllus terribilis* Roths., by Rothschild, 1903.  
*Host*.—Pika or rock-rabbit (*Ochotona princeps*).  
*Locality*.—Banff.
15. *Dactylopsylla (Foxella) ignota albertensis* (J. & R.), 1915, (1, 2).  
*Foxella ignota albertensis* (J. & R.), 1915, (3).  
*\*Ceratophyllus ignotus albertensis* J. & R., by Jordan and Rothschild, 1915 (3).  
*Hosts*.—Pocket gopher (*Geomys* sp.), weasel (*Mustela* sp.), Canada lynx (*Lynx canadensis*).  
*Localities*.—Blackfalds, Waterton, Camrose, Winterburn.
16. *Delotellus telegoni* (Roths.), 1905, (2, 3).  
*\*Ceratophyllus telegoni* Roths., by Rothschild, 1905.  
*Hosts*.—Meadow mouse (*Microtus drummondi*), red-backed mouse (*Eutamias gapperi*).  
*Locality*.—Kicking Horse Canyon.
17. *Epitedia inopina* (Roths.), 1915, (2).
24. *\*Neopsylla inopina* Roths., by Rothschild, 1915, (3).  
*Host*.—Richardson's ground squirrel (*Citellus richardsonii*).  
*Locality*.—Calgary.

18. *Epitedia wenmanni* (Roths.) 1904 (2, 3).  
\**Neopsylla wenmanni* (Roths.), by Jordan 1929.  
Hosts.—White-footed mouse (*Peromyscus leucopus*).  
Locality.—Alberta.
19. *Hoplopsyllus (Euhoplopsyllus)* sp. (Baker) 1905 (1, 2).  
Host.—Snow-shoe rabbit (*Lepus* sp.).  
Locality.—Waterton.
20. *Hystrichopsylla gigas dippiei* Roths. 1902 (1, 2, 3).  
\**Hystrichopsylla dippiei* Roths., by Rothschild 1902.  
Hosts.—Weasel (*Mustela frenata longicauda*), jack-rabbit (*Lepus* sp.), pocket gopher (*Thomomys fuscus*).  
Localities.—Alberta, Stanmore.
21. *Megarhroglossus divisus divisus* (Baker) 1898 (2, 3).  
\**Megarhroglossus longispinus* (Baker), by Rothschild 1915.  
Hosts.—Red squirrel (*Sciurus richardsoni baileyi*), mouse (*Mus* sp.).  
Locality.—Red Deer River (Rocky Mountains).
22. *Nearctopsylla brooksi* (Roths.) 1904 (2, 3).  
\**Ctenopsyllus brooksi* Roths., by Rothschild 1904.  
Hosts.—Richardson's weasel (*Mustela cicognani richardsoni*), long-tailed weasel (*Mustela longicauda*).  
Locality.—Calgary.
23. *Nearctopsylla genalis genalis* (Baker) 1904 (2, 3).  
*Nearctopsylla hygini hygini* (Roths.) 1904 (3).  
\**Ctenopsyllus hygini hygini* Roths., by Rothschild 1904.  
Hosts.—Richardson's weasel (*Mustela cicognani richardsoni*).  
Locality.—Red Deer.
24. *Neopsylla inopina* Roths., of Rothschild 1915 (1, 3).
17. \**Epitedia inopina* (Roths.) 1915 (2).  
Hosts.—Richardson's ground squirrel (*Citellus richardsonii*), long-tailed weasel (*Mustela longicauda*), red-backed mouse (*Eutamias gapperi saturatus*).  
Localities.—Calgary, Waterton, Stanmore.
25. *Odontopsyllus multispinosus* (Baker) 1898 (1, 2).  
Host.—Cotton-tail rabbit (*Sylvilagus* sp.).  
Locality.—Alberta.
26. *Orchopeas caedens* (Jordan) 1925 (2).  
*Orchopeas caedens* (Jordan) 1925 (3).  
\**Ceratophyllus caedens* Jordan, by Jordan 1925.  
Host.—Marten (*Martes americana*).  
Locality.—Banff.
27. *Orchopeas leucopus* (Baker). 1904 (2, 3).  
\**Ceratophyllus ager* Roths., by Rothschild 1905.  
\**Ceratophyllus leucopus* Baker, by Jordan, 1929.  
Hosts.—White-footed mouse (*Peromyscus maniculatus borealis*), red-backed mouse (*Eutamias gapperi saturatus*).  
Locality.—Red Deer.
28. *Orchopeas sexdentatus agilis* (Roths.) 1905 (2, 3).  
\**Ceratophyllus agilis* Roths., by Rothschild 1905.  
\**Ceratophyllus sexdentatus agilis* Roths., by Jordan 1929.  
Hosts.—Wood rat (*Neotoma cinerea*), pika or rock-rabbit (*Ochotona princeps*), Richardson's red squirrel (*Sciurus hudsonicus richardsoni*), long-tailed weasel (*Mustela longicauda*).  
Localities.—Banff, Red Deer.
29. *Oropaylla (Opisocrostitis) bruneri* (Baker) 1895 (1, 2).  
*Opisocrostitis bruneri* (Baker) 1895 (3).  
Hosts.—Richardson's ground squirrel (*Citellus richardsonii*), Columbian ground squirrel (*Citellus columbianus*), 13-striped ground squirrel (*Citellus tridecemlineatus*).  
Localities.—Sunnynook, Waterton.

30. *Oropsylla* (*Opisocrostitis*) *labis* (Jordan & Roths.) 1922 (1, 2).  
*Opisocrostitis labis* (Jordan & Roths.) 1922 (3).  
*\*Ceratomyx labis* Jordan & Roths., by Jordan and Rothschild 1922.  
*Host.*—Weasel (*Mustela longicauda*).  
*Locality.*—Calgary.
31. *Oropsylla* (*Opisocrostitis*) *tuberculata tuberculata* (Baker) 1904 (1, 2).  
*Opisocrostitis tuberculatus tuberculatus* (Baker) 1904.  
*Hosts.*—Columbian ground squirrel (*Citellus columbianus*), Richardson's ground squirrel (*Citellus richardsonii*), jack-rabbit (*Lepus* sp.).  
*Localities.*—Edmonton, Stanmore, Camrose, Youngstown, Manyberries, Brooks.
32. *Oropsylla* (*Oropsylla*) *arctomys* (Baker) 1904 (1, 2).  
*Oropsylla arctomys* (Baker) 1904 (3).  
*Host.*—Richardson's ground squirrel (*Citellus richardsonii*).  
*Locality.*—Stanmore.
33. *Oropsylla* (*Oropsylla*) *idahoensis* (Baker) 1904 (1, 2).  
*Oropsylla idahoensis* (Baker) 1904 (3).  
*\*Ceratomyx poeantis* Roths., by Rothschild 1905.  
*Hosts.*—Long-tailed weasel (*Mustela longicauda*), weasel (*Mustela* sp.), Richardson's ground squirrel (*Citellus richardsonii*), Say's mountain chipmunk (*Eutamias* sp.), burrowing owl (*Speotyto cunicularia*), mountain gopher (*Citellus* sp.), Columbian ground squirrel (*Citellus columbianus*).  
*Localities.*—Banff, Red Deer River, Atlee, Manyberries, Camrose, Stanmore.
34. *Oropsylla* (*Oropsylla*) *rupestris* (Jordan) 1929 (1, 2).  
*Oropsylla rupestris* (Jordan) (3).  
*\*Ceratomyx rupestris* Jordan 1929, by Jordan 1929.  
*Hosts.*—Weasel (*Mustela longicauda*), Richardson's ground squirrel (*Citellus richardsonii*), badger (*Taxidea taxus*), pocket gopher (*Thomomys* sp.).  
*Localities.*—Calgary, Lethbridge, Stanmore, Atlee, Waterton, Camrose, Youngstown, Sunnynook, Blackfalds, Dorothy.
35. *Peromyscopsylla hamifer hamifer* (Roths.) 1906 (2, 3).  
*\*Ctenopsyllus hamifer* Roths., by Rothschild 1906.  
*Host.*—Weasel (*Mustela* sp.).  
*Locality.*—Blackfalds.
36. *Peromyscopsylla selenis* (Roths.) 1906 (2, 3).  
*\*Ctenopsyllus selenis* Roths., by Rothschild 1906.  
*Hosts.*—Red-backed mouse (*Eutamias gapperi*), kangaroo mouse (*Zapus hudsonius*).  
*Localities.*—Red Deer, Blackfalds.
37. *Pulex irritans* Linnaeus (1, 2, 3).  
*\*Pulex irritans* L., by Jordan and Rothschild 1908.  
*Hosts.*—In house; child; lynx (*Lynx canadensis*), fox (*Vulpes velox*), badger (*Taxidea taxus*).  
*Localities.*—Vega, Dewberry, Stanmore, Edmonton, Mirror Landing.
38. *Rectofrontia fraterna* (Baker) 1895 (1, 2, 3).  
*\*Rectofrontia fraterna* (Baker), by Jordan 1937.  
*Host.*—Burrowing owl (*Speotyto cunicularia*).  
*Locality.*—Dobson.
39. *Tamiothrips grandis* (Roths.) 1902 (1, 2).  
*Hosts.*—Columbian ground squirrel (*Citellus columbianus*), Richardson's ground squirrel (*Citellus richardsonii*).  
*Locality.*—Stanmore.
40. *Thrassis acamantis* (Roths.) 1905 (1, 2).  
*Host.*—Marmot (*Marmota flaviventris avara*).  
*Locality.*—Waterton.
41. *Thrassis bacchi* (Roths.) 1905 (2, 3).  
*\*Ceratomyx bacchi* Roths., by Rothschild 1905.  
*Host.*—Thirteen-striped ground squirrel (*Citellus tridecemlineatus*).  
*Locality.*—Red Deer.

42. *Thrassis gladiolis gladiolis* (Jordan) 1925 (1, 2, 3).  
Host.—Thirteen-striped ground squirrel (*Citellus tridecemlineatus*).  
Locality.—Squaw Butte.
43. *Thrassis petiolatus* (Baker) 1904 (1, 2, 3).  
Host.—Columbian ground squirrel (*Citellus columbianus*).  
Locality.—Waterton.
44. *Trichopsylla* (*Trichopsylla*) *abantis* (Roths.) 1905 (2).  
*Megabothris abantis* (Roths.) (3).  
\**Ceratophyllus abantis* Roths., by Rothschild 1905.  
Host.—Long-tailed weasel (*Mustela longicauda*).  
Locality.—Canadian National Park, Alberta.
45. *Trichopsylla* (*Trichopsylla*) *asio asio* (Baker) 1904 (2).  
\**Megabothris asio asio* Baker, by Jordan 1933 (1).  
Host.—Weasel (*Mustela* sp.).  
Locality.—Hanna.
46. *Trichopsylla* (*Trichopsylla*) *atrox* (Jordan) 1925 (2).  
*Megabothris atrox* (Jordan) 1933 (3).  
\**Ceratophyllus atrox* Jordan, by Jordan 1925.  
Host.—Weasel (*Mustela* sp.).  
Locality.—Blackfalds.
47. *Trichopsylla* (*Trichopsylla*) *bitterrootensis* (Dunn) 1923 (2).  
*Malareus bitterrootensis* (Dunn) 1923 (3).  
\**Ceratophyllus isus* Jordan, by Jordan 1925.  
Host.—Mouse (*Mus* sp.).  
Locality.—Red Deer River (Canadian Rockies).
48. *Trichopsylla* (*Trichopsylla*) *eumolpi eumolpi* (Roths.) 1905 (1, 2).  
*Monopsyllus eumolpi eumolpi* (Roths.) 1905 (3).  
\**Ceratophyllus eumolpi* Roths., by Rothschild 1905.  
Host.—Western chipmunk (*Eutamias* sp.).  
Localities.—Banff, Red Deer, Waterton.
49. *Trichopsylla* (*Trichopsylla*) *lucifer* (Roths.) 1905 (2).  
*Megabothris lucifer* (Roths.) 1905 (3).  
\**Ceratophyllus lucifer* Roths., by Rothschild 1905.  
Host.—Meadow mouse (*Microtus drummondi*).  
Locality.—Red Deer.
50. *Trichopsylla* (*Trichopsylla*) *quirini* (Roths.) 1905 (2).  
*Megabothris quirini* (Roths.) 1905 (3).  
\**Ceratophyllus quirini* Roths., by Rothschild 1905.  
Hosts.—Red-backed mouse (*Eutamias gapperi*), red-backed mouse (*Eutamias gapperi saturatus*).  
Locality.—Red Deer.
51. *Trichopsylla* (*Trichopsylla*) *thamba* (Jordan) 1929 (2).  
*Monopsyllus thambus* (Jordan) 1929 (3).  
\**Ceratophyllus thambus* Jordan, by Jordan 1929.  
Host.—Lynx (*Lynx canadensis*).  
Locality.—Red Deer.
52. *Trichopsylla* (*Trichopsylla*) *vison* (Baker) 1904 (1, 2).  
*Monopsyllus vison* (Baker) 1904 (3).  
\**Ceratophyllus vison* Baker, by Jordan 1929.  
Hosts.—Chipmunk (*Eutamias* sp.), pine squirrel (*Sciurus hudsonicus*).  
Locality.—Waterton, Alberta.
53. *Trichopsylla* (*Trichopsylla*) *wagneri systalta* (Jordan) 1929 (1, 2).  
*Monopsyllus wagneri systaltus* (Jordan) 1929 (3).  
\**Ceratophyllus wagneri systaltus* Jordan, by Jordan 1929.  
Host.—White-footed mouse (*Peromyscus* sp.).  
Localities.—Red Deer, Blackfalds, Waterton.

## A LIST OF KNOWN PLAGUE VECTORS

1. *Orchopeas sexdentatus agilis* (Roths.) 1905.  
*Hosts*.—Wood rat (*Neotoma cinerea*), pika or rock-rabbit (*Ochotona princeps*), Richardson's red squirrel (*Sciurus richardsoni*), long-tailed weasel (*Mustela longicauda*).  
*Localities*.—Banff, Red Deer.
2. *Oropsylla (Oropsylla) idahoensis* (Baker) 1904.  
*Hosts*.—Long-tailed weasel (*Mustela longicauda*), weasel (*Mustela* sp.), Richardson's ground squirrel (*Citellus richardsoni*), Say's mountain chipmunk (*Eutamias* sp.), burrowing owl (*Speotyto cunicularia*), mountain gopher (*Citellus* sp.), Columbian ground squirrel (*Citellus columbianus*).  
*Localities*.—Banff, Red Deer River, Atlee, Manyberries, Camrose, Stanmore.
3. *Oropsylla (Opisocrostitis) labis* (Jordan & Roths.) 1922.  
*Host*.—Weasel (*Mustela longicauda*).  
*Locality*.—Calgary.
4. *Oropsylla (Oropsylla) rupestris* (Jordan) 1929.  
*Hosts*.—Weasel (*Mustela* sp.), Richardson's ground squirrel (*Citellus richardsoni*), badger (*Taxidea taxus*), pocket gopher (*Thomomys* sp.).  
*Localities*.—Calgary, Lethbridge, Stanmore, Atlee, Waterton, Camrose, Youngstown, Sunnynook, Blackfalds, Dorothy.
5. *Oropsylla (Opisocrostitis) tuberculata tuberculata* (Baker) 1904.  
*Hosts*.—Columbian ground squirrel (*Citellus columbianus*), Richardson's ground squirrel (*Citellus richardsoni*), jack-rabbit (*Lepus* sp.).  
*Localities*.—Edmonton, Stanmore, Camrose, Youngstown, Manyberries, Brooks.
6. *Pulex irritans* Linnaeus 1758.  
*Hosts*.—In house; child; lynx (*Lynx canadensis*), fox (*Vulpes velox*), badger (*Taxidea taxus*).  
*Localities*.—Vega, Dewberry, Stanmore, Edmonton, Mirror Landing.
7. *Thrassis acamantis* (Roths.) 1905.  
*Host*.—Marmot (*Marmota flaviventris avara*).  
*Locality*.—Waterton.
8. *Thrassis gladiolus gladiolus* (Jordan) 1925.  
*Host*.—Thirteen-striped ground squirrel (*Citellus tridecemlineatus*).  
*Locality*.—Squaw Butte.
9. *Thrassis petiolatus* (Baker) 1904.  
*Host*.—Columbian ground squirrel (*Citellus columbianus*).  
*Locality*.—Waterton.
10. *Trichopsylla (Trichopsylla) eumolpi eumolpi* (Roths.) 1905.  
*Host*.—Western chipmunk (*Eutamias* sp.).  
*Localities*.—Banff, Red Deer, Waterton.
11. *Trichopsylla (Trichopsylla) thamba* (Jordan).  
*Host*.—Lynx (*Lynx canadensis*).  
*Locality*.—Red Deer.

## A LIST OF HOSTS FROM WHICH PLAGUE VECTORS HAVE BEEN RECOVERED

1. **Badger** (*Taxidea taxus*).  
*Vectors*: *Oropsylla (Oropsylla) rupestris* Jordan 1929.  
*Pulex irritans* Linnaeus 1758.
2. **Burrowing owl** (*Speotyto cunicularia*).  
*Vectors*: *Oropsylla (Oropsylla) idahoensis* Baker 1904.
3. **Child**.  
*Vector*: *Pulex irritans* Linnaeus 1758.
4. **Columbian ground squirrel** (*Citellus columbianus*).  
*Vectors*: *Oropsylla (Oropsylla) idahoensis* Baker 1904.  
*Oropsylla (Opisocrostitis) tuberculata tuberculata* Baker 1904.  
*Thrassis petiolatus* Baker 1904.

5. **Coyote** (*Canis latrans*).  
Vector: *Oropsylla* (*Oropsylla*) *rupestris* Jordan 1929.
6. **Fox** (*Vulpes velox*).  
Vector: *Pulex irritans* Linnaeus 1758.
7. **Jack-rabbit** (*Lepus* sp.).  
Vector: *Oropsylla* (*Opisocrostis*) *tuberculata tuberculata* Baker 1904.
8. **Lynx** (*Lynx canadensis*).  
Vectors: *Pulex irritans* Linnaeus 1758.  
*Trichopsylla* (*Trichopsylla*) *thamba* Jordan 1929.
9. **Marmot** (*Marmota flaviventris avara*).  
Vector: *Thrassis acamantis* Rothschild 1905.
10. **Pocket gopher** (*Thomomys* sp.).  
Vector: *Oropsylla* (*Oropsylla*) *rupestris* Jordan 1929.
11. **Richardson's ground squirrel** (*Citellus richardsonii*).  
Vectors: *Oropsylla* (*Oropsylla*) *idahoensis* Baker 1904.  
*Oropsylla* (*Oropsylla*) *rupestris* Jordan 1929.  
*Oropsylla* (*Opisocrostis*) *tuberculata tuberculata* Baker 1904.
12. **Richardson's red squirrel** (*Sciurus richardsoni*).  
Vector: *Orchopeas sexdentatus agilis* Roths. 1905.
13. **Rock-rabbit or pika** (*Ochotona princeps*).  
Vector: *Orchopeas sexdentatus agilis* Roths. 1905.
14. **Say's mountain chipmunk** (*Eutamias* sp.).  
Vectors: *Oropsylla* (*Oropsylla*) *idahoensis* Baker 1904.  
*Trichopsylla* (*Trichopsylla*) *eumolpi eumolpi* Roths. 1905.
15. **Weasel** (*Mustela* sp.).  
Vectors: *Orchopeas sexdentatus agilis* Roths. 1904.  
*Oropsylla* (*Oropsylla*) *idahoensis* Baker 1904.  
*Oropsylla* (*Opisocrostis*) *labis* Jordan & Roths. 1922.  
*Oropsylla* (*Oropsylla*) *rupestris* Jordan 1929.
16. **Wood rat** (*Neotoma cinerea*).  
Vector: *Orchopeas sexdentatus agilis* Roths. 1905.
17. **Thirteen-striped ground squirrel** (*Citellus tridecemlineatus*).  
Vector: *Thrassis gladiolis gladiolis* Jordan 1925.

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# HEAD-CAPSULE MEASUREMENTS OF SOUTHERN ARMYWORM LARVAE (*PRODENIA ERIDANIA* (CRAMER) )

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The observation by Dyar (1890) that the sclerotized parts of insects do not change in area during a stadium but increase only at ecdysis led to the generalization that the changes in width of the head capsule of a larva in its successive stages usually follow a regular geometric progression, and this generalization has become known as Dyar's rule. This rule has been used by Taylor (1931), Gaines and Campbell (1935), Peterson and Haeussler (1928), and others to determine the number of instars undergone by certain larvae and also to determine if the observed number of molts coincided with the number required if Dyar's rule was applicable.

The width of the head capsule of each larval instar of the southern armyworm (*Prodenia eridania* (Cram.)) was given in a technical description of the egg and larval stages of this insect, contributed by Dyar for inclusion in a publication by Chittenden and Russell (1909). His figures were obtained by measuring the head width of a relatively few larvae that were collected in the field.

Large numbers of southern armyworm larvae that were reared in greenhouse cages have been used in the laboratories of the Division of Control Investigations at Beltsville, Md., for various physiological and toxicological experiments, and it has become increasingly necessary to be able to determine the instar to which a given larva belongs. With this purpose in mind, and also to determine if the head measurements given in the publication by Chittenden and Russell are applicable to these greenhouse-reared larvae, the widths of the head capsules of over two thousand larvae of all ages and sizes have been determined. The present paper is based on these measurements and their statistical analysis.

## METHODS

In the laboratories previously mentioned, the young southern armyworm larvae are normally placed on turnip foliage immediately after they have hatched and remain on this foodstuff until they are about 10 days old, after which they are fed collard leaves until feeding ceases. The larvae are kept in greenhouse cages that are maintained at 75° to 85° F. during the winter months by the use of soil-heating cables in the bottoms of the cages. During the summer no temperature control is attempted. For the purposes of these experiments some larvae were fed in the normal manner, others were reared through on turnip foliage alone, and still others were reared in individual containers so that the head sizes of single larvae could be determined throughout the

larval cycle. The size of the cast head capsules of these last larvae were compared with the size of the head before molting took place.

All measurements were made by the use of a calibrated ocular micrometer.

## RESULTS, CALCULATIONS, AND DISCUSSION

The widths of the head capsules of all larvae measured ranged between 0.2424 and 2.9896 mm. Figure 1 shows the results of grouping all larvae, except those reared in individual containers, according to head-capsule size, each group representing an instar.

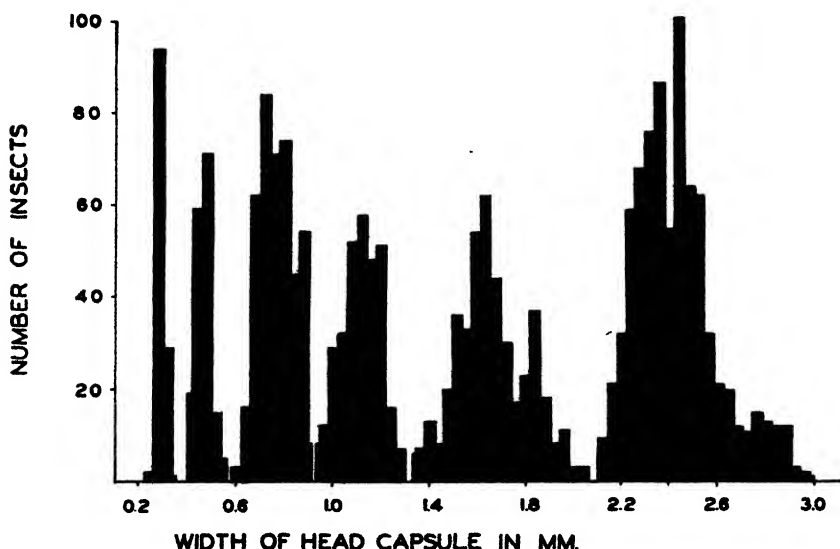


FIGURE 1. Histogram showing frequency distribution of head-capsule widths of the southern armyworm.

The mean head width of each instar was then determined and the growth ratio was found by dividing each mean by the mean preceding it. According to statistical theory (Fisher, 1930), a deviation exceeding 1 standard deviation occurs about once in 3 trials, and twice the standard deviation is exceeded only about once in 22 trials. In an effort, therefore, to determine the possible limits of each instar, the mean  $\pm 1$  standard deviation and the mean  $\pm 2$  standard deviations were determined. The results are shown in Table I.

It is apparent that there are six well-defined groups, or instars, but it must be noted that in four instars, the first, second, third, and fifth, the observed limits of the instar are exceeded by neither the upper nor the lower limit of two standard deviations from the mean. For this reason, when a larva of a given instar is desired, the practice has been adopted of selecting only those whose head-capsule measurements are

within one standard deviation of the mean for that instar. The instar sizes of field-collected larvae as given by Dyar in the publication by Chittenden and Russell correspond closely with those found in this laboratory.

TABLE I  
DATA CONCERNING HEAD-CAPSULE WIDTHS AND INSTARS OF THE  
SOUTHERN ARMYWORM

Instar Number	1	2	3	4	5	6
Observed limits of instar (mm.) . . .	0.24-0.34	0.40-0.59	0.61-0.91	0.93-1.27	1.29-2.06	2.10-2.99
Mean (mm.) . . . . .	.29	.47	.77	1.11	1.66	2.41
Growth ratio . . . . .		1.62	1.65	1.45	1.49	1.45
Standard deviation (mm.) . . . . .	.016	.037	.066	.083	.148	.171
Limits of $M \pm 1$ standard deviation (mm.)	.27-.31	.43-.51	.70 .84	1.03-1.19	1.51-1.81	2.24-2.58
Limits of $M \pm 2$ standard deviations (mm.) . . . . .	.26-.32	.40-.54	.64-.90	.94-1.28	1.38-1.94	2.07-2.75
Number of individuals observed . . . . .	126	170	407	311	436	788
Duration of instar (days) . . . . .	5	3.5	3	3	5	8.5

In an experiment head-capsule measurements were made on a number of live larvae, some on cast head capsules, and some others on larvae that had been preserved in alcohol. For a given instar no significant difference in size between these three groups was found. In Table II measurements are given of cast head capsules of 100 larvae that were reared through to pupation in small individual containers.

TABLE II  
DATA ON 100 SOUTHERN ARMYWORM LARVAE REARED ENTIRELY ON TURNIP  
FOLIAGE IN INDIVIDUAL CONTAINERS

Instar number . . . . .	1	2	3	4	5	6
Mean width of head capsule of cast skin of 98 larvae, in mm. . . . .	0.28	0.46	0.75	1.18	1.82	2.77
Growth ratio . . . . .		1.64	1.63	1.58	1.54	1.53
Mean width of the head capsule of the cast skin of two larvae that pupated after 5 instars . . . . .	0.26	0.44	0.78	1.27	2.30	pupa

These were fed turnip foliage only. Two of these larvae, however, pupated at the end of five instars instead of the normal six. The mean measurement for the first instar of these two abnormal larvae is 0.01 mm. below the lower limit of the mean  $\pm 1$  standard deviation found in Table I for the corresponding instar. The second and third lie between these limits but the fourth and fifth were considerably at variance.

That food is apparently an important factor is shown by the variation in growth ratios soon after the larvae begin feeding on collards, the growth ratios for the turnip-leaf-fed fifth and sixth instars being considerably above those of the larvae that were fed collards after the third instar. Since this observation is based on the behavior of only 100 larvae, however, it may not be generally correct.

If Dyar's rule is strictly correct, the growth ratios for all instars should be the same, and any irregularity in the progression would denote the omission of an instar. There is considerable variation in the

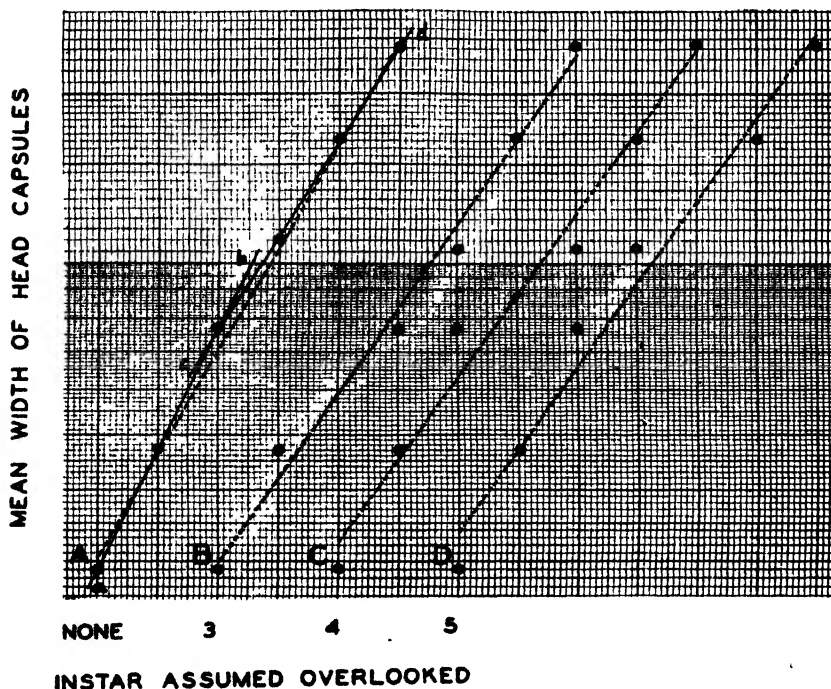


FIGURE 2. Relation of calculated progression to observed head measurements (graph made on semi-log paper). The dotted line A is the line of best fit for the observed measurements, calculated from the equation  $\log Y = \log a + (\log b) X$ . The dotted lines B, C, and D are calculated in a similar manner but under the assumption that the third, fourth, and fifth instars, respectively, had been overlooked. The lines *ab* and *cd* show the departure of the observed values for the third instar from a geometric progression.

growth ratios of the various instars, as is shown in Tables I and II, but not so much as was found by Gaines and Campbell (1935) in their work on the corn earworm. These authors pointed out that if the head widths were in a geometrical progression, the best estimate of the growth ratio would be obtained by converting the measurements to logarithms and by the method of least squares determining the constants  $a$  and  $b$  of the equation  $\log Y = \log a + (\log b) X$ . In this equation antilog  $Y$  is the

TABLE III

COMPARISON OF OBSERVED AND CALCULATED VALUES, IN MILLIMETERS, OF THE MEAN WIDTH OF THE HEAD CAPSULE OF THE SOUTHERN ARMYWORM, WHEN IT WAS ASSUMED THAT SUCCESSIVE INSTARS HAD BEEN OVERLOOKED

Instar Assumed to Have Been Overlooked	First Instar	Second Instar	Third Instar	Fourth Instar	Fifth Instar	Sixth Instar	Seventh Instar	Standard Error of Estimate	Mean Growth Ratio
	<i>Mm.</i>	<i>Mm.</i>	<i>Mm.</i>	<i>Mm.</i>	<i>Mm.</i>	<i>Mm.</i>	<i>Mm.</i>	<i>Mm.</i>	
None.....	Observed mean.....	0.286	0.769	1.114	1.658	2.409	2.409	.....	.....
	Calculated mean.....	.304	.710	1.084	1.657	2.531	2.531	.....	.....
	Difference.....	— .018	+ .059	+ .030	+ .001	— .122	— .122	0.066	1.53
Second.....	Observed mean.....	.286	.465	.769	1.114	1.658	2.409	.....	.....
	Calculated mean.....	.259	.374	.776	1.119	1.614	2.327	.....	.....
	Difference.....	+ .027	— .074	— .007	— .005	+ .044	+ .082	0.061	1.44
Third.....	Observed mean.....	.286	.465	.769	1.114	1.658	2.409	.....	.....
	Calculated mean.....	.297	.418	.589	1.166	1.642	2.311	.....	.....
	Difference.....	— .011	+ .047	— .060	— .052	+ .016	+ .098	0.068	1.41
Fourth.....	Observed mean.....	.286	.465	.769	1.114	1.658	2.409	.....	.....
	Calculated mean.....	.324	.451	.629	.877	1.223	1.705	.....	.....
	Difference.....	— .038	+ .014	+ .140	— .109	— .047	— .047	0.095	1.39
Fifth.....	Observed mean.....	.286	.465	.769	1.114	1.658	2.409	.....	.....
	Calculated mean.....	.337	.472	.662	.928	1.30	2.555	.....	.....
	Difference.....	— .051	— .007	+ .107	+ .186	— .165	— .146	0.156	1.40
Sixth.....	Observed mean.....	.286	.465	.769	1.114	1.658	2.409	.....	.....
	Calculated mean.....	.335	.480	.689	.989	1.420	2.923	.....	.....
	Difference.....	— .049	— .015	+ .080	+ .125	+ .238	— .514	0.294	1.44

estimated head width for the given instar ( $X$ ),  $\log a$  is the first term, and  $\log b$  is the slope of the line, or the logarithm of the desired growth ratio. For the purpose of calculation they then assumed that they had overlooked the second instar, the observed second instar then became the third, the observed third the fourth, and so on. The method of least squares was then applied and the progression so calculated was compared with their original calculated progression and a line of much better fit was obtained. Gaines and Campbell were certain that they had not missed an instar in their observations and decided that the application of Dyar's rule by the method of least squares did not corroborate the number of instars observed by them.

The values herein reported for the head sizes of the southern armyworm were treated in a similar manner. The lines of best fit were also calculated when each of the six instars was assumed to have been overlooked. The assumption that the first instar had been overlooked before any molts were observed is not included in Table III since all deviations were found to be exactly the same as when no instar was assumed to have been overlooked. In the unlikely case that the first molt had been completely overlooked this statistical procedure would offer no help in the detection of the oversight. As may be seen in the table the standard error of estimate, as calculated from observed deviations, for the case of not having overlooked any instar is 0.066 mm. When having assumed the omission of the second instar this figure is smaller but not significantly so whereas all the others are increasingly larger. The results of these calculations are shown in Table III and the graph on semi-log paper (fig. 2).

When the standard errors were calculated from logarithms and expressed as percentages the values were 5.8, 8.9, 7.5, 13.5, 15.8, and 16.6. This method represents the variance that is minimized by the process used. From these figures it may be concluded that the smallest relative standard error of estimate is associated with the series in which no instar was assumed to be missing and that the other errors taken in turn belong to corresponding series in which it is assumed that successive instars have been overlooked.

In this study well over 2,000 larvae were measured. These larvae were taken from the cages over a period of 8 months.

The plot of the observed mean widths does not show a haphazard deviation, but a rather sharp break occurs in the curve at the third instar. A similar break at the third instar occurs in Gaines' and Campbell's plot of the mean width of the head of the corn earworm (*Heliothis armigera* (Hbh.)). The growth ratios of the late instars of both insects are considerably smaller than those of the earlier ones and possibly may correspond to some definite but as yet unknown change in the physiological state of the insects.

## SUMMARY AND CONCLUSIONS

Measurements of the head-capsule sizes of over 2,000 larvae of all stages of the southern armyworm (*Prodenia eridania*) were made and were found to vary between 0.24 and 2.99 mm.

The larvae were grouped according to size of the head capsule to determine the frequency distribution. The larvae fell in six well defined groups corresponding to six instars. The mean  $\pm 1$  standard deviation in millimeters for the first instar was  $0.29 \pm 0.016$ ; for the second,  $0.47 \pm 0.037$ ; for the third,  $0.77 \pm 0.066$ ; for the fourth,  $1.11 \pm 0.083$ ; for the fifth,  $1.66 \pm 0.148$ ; and for the sixth,  $2.41 \pm 0.171$ .

The means were plotted logarithmically against the number of the instar, and the straight line of best fit was calculated by the method of least squares. From the data it was concluded that growth ratios tend to fall in a geometric progression, and that with this species there are only six instars. Results tend to throw doubt on the usefulness of Dyar's rule to detect missing instars.

A sharp break in the plot of the mean head capsule widths occurred at the third instar, the points apparently following regular progressions above and below this break. This break may correspond to a definite change in the physiological state of the insect.

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CHECKLIST OF THE COLEOPTEROUS INSECTS OF MEXICO, CENTRAL AMERICA, THE WEST INDIES AND SOUTH AMERICA. Part 1. Compiled by RICHARD E. BLACKWELDER. U. S. Nat. Mus. Bull. 185; 188 pages. 1944. For sale by Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. Price \$0.35.

This first part of a list of Coleoptera south of the United States is the beginning of a series of lists planned by the Smithsonian Institution and the U. S. National Museum. The present part covers about thirty of the one hundred and twenty families of Coleoptera to be covered. It follows the Böving and Craighead list in "Synopsis of Larval Coleoptera," 1931, which arrangement was approved by the Peyerimhoff classification of 1933.

The Preface in English is repeated in Portuguese, in Spanish and in French. Lack of space apparently prevented the repetition of it in German for the many savants using that language in South America. We hope the small type used does not restrict its use to the younger men with good eyes.—C. H. K.

## BIOLOGY OF IXODES MURIS BISHOPP AND SMITH (IXODIDAE)<sup>1</sup>

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*Ixodes muris* was described in 1937 by Bishopp and Smith<sup>2</sup> from larvae, nymphs, males, and females collected in Massachusetts. The hosts reported in this paper were the jumping mouse, the meadow mouse, the white-footed mouse, the Norway rat, the short-tailed shrew, and the muskrat. The localities from which collections were made were Cape Cod and the islands of Martha's Vineyard and Nantucket. There have been no subsequent publications on this species, and the biology was unknown at the time this study was started.

No common name has as yet been given to this species, but it seems that "the mouse tick" would be appropriate, as its normal hosts in all stages are the various species of mice and rats. This name is accordingly proposed for it.

**Hosts and Distribution.**—During the course of this study the following new host records have been obtained: dog, Edgartown, Mass., April 22, 1938, 1 female; long-tailed shrew, Edgartown, Mass., May 11, 1939, 8 larvae, 2 nymphs; cotton-tail rabbit, Oak Bluffs, Mass., October 11, 1938, 1 female; cotton-tail rabbit, Edgartown, Mass., April 27, 1940, 1 female; cotton-tail rabbit, Edgartown, Mass., June 14, 1940, 3 larvae. Additional records have been obtained from all hosts listed by Bishopp and Smith<sup>2</sup>. The most important host by far is the meadow mouse, because of its numbers, wide distribution, and susceptibility. Only the white-footed mouse rivals it in the first two respects. Whereas 864 larvae, 346 nymphs, and 63 females were found on 2,553 meadow mice, only 57 larvae, 26 nymphs, and 9 females were found on 714 white-footed mice captured at the same times and places.

An additional distribution record was obtained when two larvae were found on a meadow mouse captured at Melvin Village, N. H., June 28, 1940.

**Methods of Study.**—Experimental studies on the biology of the mouse tick were started at Vineyard Haven, Mass., in March 1938, using specimens of all stages collected in nature or reared in the laboratory. Records on molting of engorged larvae and nymphs and on preovipo-

<sup>1</sup>A portion of a thesis submitted to the Graduate Council of the George Washington University in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

<sup>2</sup>Bishopp, F. C., and C. N. Smith, 1937. A New Species of *Ixodes* from Massachusetts. Proc. Ent. Soc. Wash., 39: 133-138.



sition, oviposition, and incubation of eggs from engorged females were obtained under outdoor conditions from ticks kept in rearing tubes and under incubator or room conditions from ticks kept in rearing tubes or in pill boxes set on moist sand. Records on the longevity of all stages under all conditions were obtained from ticks kept in rearing tubes. The rearing tubes were prepared from test tubes of soft glass 6 inches long and  $\frac{3}{4}$  inch wide. The glass bottoms were removed, and a new bottom was made by tamping in a moist mixture of clay loam and sand. This mixture conducts water readily, is firm, and will not draw away from the sides of the tube if drying occurs. The tubes were kept in pans of moist sand indoors and in the soil outdoors. Light cloth tops confined the ticks in the tubes but gave good ventilation and permitted rapid evaporation of excess moisture after rains.

In obtaining the outdoor records the tubes were kept under two conditions so that the possibility of using abnormal records might be reduced. One lot of tubes was simply set in the soil to a depth of 2 inches, so that they were exposed to direct sunlight and rainfall as well as to all variations of temperature, humidity, and air circulation. These are referred to in subsequent tables as being "outdoors uncovered." The other lot of tubes was set in the soil under crates with roofing paper tops and sides of wood strips and screening, so that they were sheltered from direct rainfall and sunlight, but exposed to all variations of temperature, humidity, and air circulation. These are referred to as being in the "outdoor breeding cage." As will be shown later, no very great differences were noted between the records from the two locations, an indication that those from both were probably about normal.

All stages were engorged on meadow mice or other rodents confined in wire cages over pans of water, from which the ticks which had completed feeding and dropped were collected daily.

Records on seasonal abundance were based on collections of ticks from mice taken in nature. As ticks begin to leave the host shortly after its death, it was necessary to capture the animals alive rather than use traps that killed them, in order to obtain more reliable data on complete infestation. Box-type traps were used successfully. At first the mice caught in this way were etherized and the ticks removed, but later they were kept in cages over moats to permit the ticks to engorge and drop, as in the case of experimentally infested animals.

*Oviposition.*—The daily oviposition records of 7 engorged females and a description of them are presented in Tables I and II. It will be noted that the smallest total number of eggs deposited by a female was 135 and the largest 1,380. The average number of eggs deposited per female was 656, a very small number in comparison with those produced by other members of this family. The females required 7 to 25 days to deposit all their eggs, laying as many as 165 in a single day. Oviposition was influenced to some extent by the temperature, the most eggs being deposited on warm days. Two females died the day after oviposition was completed, whereas 5 lived for 1 to 13 additional days. One female, not shown in the table, lived for more than a month.

TABLE I  
DESCRIPTION OF FEMALES USED FOR OVIPOSITION RECORDS

Female No.	Date of Dropping	Location of Female	Size of Female, mm.
	1939		
1	Apr. 10 . . .	Outdoor breeding cage	7.3 x 5.4 x 4.2
2	May 1 . . .	do	7.9 x 5.7 x 4.6
3	29 . . .	Outdoors uncovered	7.2 x 5.0 x 4.5
4	July 11 . . .	Outdoor breeding cage	7.1 x 5.4 x 4.9
5	19 . . .	Outdoors uncovered	7.8 x 5.9 x 5.0
6	25 . . .	do	8.2 x 6.0 x 5.5
	1940		
7	June 3 . . .	do	7.0 x 5.0 x 4.6

TABLE II  
DAILY OVIPOSITION RECORD OF SEVEN FEMALES

Day After Dropping	Number of Eggs Laid by Female No.							Day After Dropping	Number of Eggs Laid by Female No.						
	1	2	3	4	5	6	7		1	2	3	4	5	6	7
8 . . .					24	22		37 . . .		*					*
9 . . .				75	94	34		38 . . .	10		*				
10 . . .				88		81		39 . . .	15						
								40 . . .							
11 . . .				65	99	25									
12 . . .				149	63	108		41 . . .							
13 . . .				66	113	149		42 . . .	16						
14 . . .			28	165	35	18		43 . . .	29			*			
15 . . .			70	123	*	13	14	44 . . .	30						
16 . . .			26	111		*	49	45 . . .	43						
17 . . .			29	91			32	46 . . .	54						
18 . . .			37	117				47 . . .	49						
19 . . .			39	69			41	48 . . .	88						
20 . . .			52	52			42	49 . . .	91						
								50 . . .	68						
21 . . .			30	74			36								
22 . . .			62	45			29	51 . . .	81						
23 . . .			81	30			29	52 . . .	27						
24 . . .			47	25			40	53 . . .	38						
25 . . .			46	16			31	54 . . .	24						
26 . . .			45				28	55 . . .	31						
27 . . .		6	54	12			10	56 . . .	40						
28 . . .		39	24				41	57 . . .	30						
29 . . .		47	23				23	58 . . .	19						
30 . . .			41	7			19	59 . . .	27						
								60 . . .	12						
31 . . .		2	37				15								
32 . . .		24	29				3	61 . . .	8						
33 . . .		17	35				9	62 . . .	3						
34 . . .			19				13	63 . . .							
35 . . .			3				1	64 . . .	1						
36 . . .			3												
Total . . .								833 136 860 1380 428 450 505							

\*Female died.

**TABLE III**  
**PREOVIPPOSITION, INCUBATION, AND LARVAL LONGEVITY**

Date Female Dropped	Location of Female	Date of First Oviposition	Date of First Hatch	Date Some Larvae Last Seen Alive.	Date All Larvae Were Dead	Pre- oviposition Period, Days	Incubation Period, Days	Larval Longevity, Days
1938		1938	1938					
May 7	Incubator.	May 20	June 19	July 9, 1938*	.....	13	30	.....
May 11	do	June 11	July 19	July 26, 1938*	.....	7	31	.....
June 4	do	June 11	July 19	.....	.....	7	31	291-331
June 19	Fleated room	July 11-26	Aug. 29	June 16, 1939	July 25, 1939	1-7	34-41	144-183
July 19	Incubator.	Oct. 28	Nov. 18	Apr. 11, 1939	May 20, 1939	6	21	184-211
Oct. 19	do	Oct. 25	Nov. 18	May 20, 1939	June 16, 1939	6	23	.....
1939		1939	1939					
Apr. 10	Outdoors uncovered	May 9-12	July 8	Aug. 24, 1939*	.....	29-32	57-60	.....
May 11	do	May 12	July 7	May 10, 1940	June 14, 1940	29-31	56-59	358-343
May 12	Outdoor breeding cage	May 12	July 7	Oct. 15, 1939	Nov. 20, 1940	35	52	461-497
May 19	Outdoors uncovered	May 31	July 12	Dec. 18, 1939*	.....	25	43	.....
May 25	do	June 6	July 21	do	.....	25	43	.....
May 30	do	June 2	July 14	do	.....	14	45	.....
June 2	do	June 2	July 14	do	.....	14	45	.....
June 7	do	June 7	July 14	do	.....	14	45	.....
June 16-17	Outdoor breeding cage	June 16-17	Aug. 6	June 14, 1940	July 18, 1940	14	45	336-370
June 16	Outdoors uncovered	June 16	Aug. 6	Aug. 15, 1940	Aug. 15, 1940	14	47	368-396
June 17	Outdoor breeding cage	July 27	Aug. 24	Oct. 11, 1940*	Sept. 18, 1940	13	47	388-422
June 18	Outdoors uncovered	July 27	Aug. 24	do	.....	13	47	.....
June 19	do	July 27	Aug. 24	Sept. 15, 1940	Nov. 20, 1940	1-9	35-51	418-454
June 20	do	July 27	Aug. 24	Sept. 15, 1940	Oct. 18, 1940	9	35	389-446
June 21	do	July 27	Aug. 24	Sept. 15, 1940	Oct. 18, 1940	9	35	391-325
June 22	do	July 27	Aug. 24	Sept. 15, 1940	Oct. 18, 1940	9	35	392-399
June 23	do	July 27	Aug. 24	Sept. 15, 1940	Oct. 18, 1940	9	35	393-397
June 24	do	July 27	Aug. 24	Sept. 15, 1940	Oct. 18, 1940	9	35	394-397
June 25	do	July 27	Aug. 24	Sept. 15, 1940	Oct. 18, 1940	9	35	395-397
June 26	do	July 27	Aug. 24	Sept. 15, 1940	Oct. 18, 1940	9	35	396-397
June 27	do	July 27	Aug. 24	Sept. 15, 1940	Oct. 18, 1940	9	35	397-397
June 28	do	July 27	Aug. 24	Sept. 15, 1940	Oct. 18, 1940	9	35	398-396
June 29	Outdoor breeding cage	*Aug. 2	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	420-479
June 30	Outdoors uncovered	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	421-479
July 1	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	422-479
July 2	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	423-479
July 3	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	424-479
July 4	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	425-479
July 5	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	426-479
July 6	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	427-479
July 7	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	428-479
July 8	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	429-479
July 9	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	430-337
July 10	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	431-498
July 11	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	432-498
July 12	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	433-498
July 13	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	434-498
July 14	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	435-498
July 15	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	436-498
July 16	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	437-498
July 17	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	438-498
July 18	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	439-498
July 19	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	440-498
July 20	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	441-498
July 21	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	442-498
July 22	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	443-498
July 23	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	444-498
July 24	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	445-498
July 25	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	446-498
July 26	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	447-498
July 27	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	448-498
July 28	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	449-498
July 29	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	450-498
July 30	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	451-498
July 31	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	452-498
Aug. 1	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	453-498
Aug. 2	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	454-498
Aug. 3	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	455-498
Aug. 4	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	456-498
Aug. 5	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	457-498
Aug. 6	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	458-498
Aug. 7	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	459-498
Aug. 8	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	460-498
Aug. 9	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	461-498
Aug. 10	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	462-498
Aug. 11	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	463-498
Aug. 12	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	464-498
Aug. 13	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	465-498
Aug. 14	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	466-498
Aug. 15	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	467-498
Aug. 16	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	468-498
Aug. 17	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	469-498
Aug. 18	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	470-498
Aug. 19	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	471-498
Aug. 20	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	472-498
Aug. 21	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	473-498
Aug. 22	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	474-498
Aug. 23	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	475-498
Aug. 24	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	476-498
Aug. 25	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	477-498
Aug. 26	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	478-498
Aug. 27	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	479-498
Aug. 28	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	480-498
Aug. 29	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	481-498
Aug. 30	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	482-498
Aug. 31	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	483-498
Sept. 1	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	484-498
Sept. 2	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	485-498
Sept. 3	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	486-498
Sept. 4	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	487-498
Sept. 5	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	488-498
Sept. 6	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	489-498
Sept. 7	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	490-498
Sept. 8	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	491-498
Sept. 9	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	492-498
Sept. 10	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	493-498
Sept. 11	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	494-498
Sept. 12	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	495-498
Sept. 13	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	496-498
Sept. 14	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	497-498
Sept. 15	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	498-498
Sept. 16	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	499-498
Sept. 17	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	500-498
Sept. 18	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	501-498
Sept. 19	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	502-498
Sept. 20	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	503-498
Sept. 21	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	504-498
Sept. 22	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	505-498
Sept. 23	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	506-498
Sept. 24	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	507-498
Sept. 25	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	508-498
Sept. 26	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	509-498
Sept. 27	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	510-498
Sept. 28	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	511-498
Sept. 29	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	512-498
Sept. 30	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	513-498
Sept. 31	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	514-498
Oct. 1	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	515-498
Oct. 2	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	516-498
Oct. 3	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	517-498
Oct. 4	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	518-498
Oct. 5	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	519-498
Oct. 6	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	520-498
Oct. 7	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	521-498
Oct. 8	do	Aug. 1	Sept. 7	Nov. 20, 1940	Jan. 9, 1941	4	34	522-498
Oct. 9	do	Aug. 1	Sept. 7	Nov. 20, 1940				

**\* Engorged.**

**Preoviposition.**—Preoviposition records on ticks held under outdoor conditions, in an incubator at 80° F. and in a heated room, are presented in Table III. In the incubator the preoviposition period ranged from 6 to 13 days and under outdoor conditions from 6 to more than 268 days, as females which completed engorgement between the middle of August and the middle of September did not begin oviposition until the following spring. Since females are active in nature until the end of September, it must be assumed that this wide variation in the preoviposition period is a frequent and normal occurrence.

**Incubation of Eggs.**—The incubation period ranged from 21 to 31 days in the incubator and from 31 to between 66 and 77 days outdoors (Table III). It will be noted that oviposition beginning as late as August 15, 1939, from females dropping on August 1, resulted in hatching the same fall, beginning September 18. This hatching was completed by October 13. As females which dropped only 2 weeks later, August 16, did not oviposit until the next spring, no egg masses would be subjected to the winter. This would seem to be a definite provision of the developmental cycle to assure that a susceptible stage, the egg, would not be destroyed by the onset of winter. Only one batch of eggs was actually exposed over winter, that from the female shown to have dropped July 26, 1939. Hatching began September 13, but whereas the four later lots all completed hatching during September and October, only seven eggs of this lot hatched during the fall, although the other eggs all showed white viable spots. None of these eggs hatched the next spring, but as they had developed abnormally in September and October it cannot definitely be said that they were killed by the winter.

The earliest hatching in 1939 occurred on July 7, from eggs laid by a female dropped April 11, and only a week later, July 14, there was hatching from eggs laid by a female that had not dropped until May 16. In 1940 eggs from overwintered females began hatching between July 8 and July 14, and eggs from females engorged the same spring, April 9 and May 11, began hatching July 20.

**Larval Longevity.**—The larvae are able to survive exposure to the winter satisfactorily and engorge normally the following spring, as shown in Table III. These were not cases of only a few larvae surviving, but the majority of the individuals in the lots came through in good condition, clustered in dense masses on the walls of the tubes. In April and May these clusters began to break up, the larvae crawling about individually. It will be noted that the longevity of lots kept outdoors ranged from about 130 to 490 days. Although no lot survived two winters, several lots lived through two complete seasons of larval activity.

**Larval Engorgement.**—The larvae were easily induced to feed on meadow mice, and records on engorgement were obtained without difficulty, as many as 649 engorging at one time on one mouse. Records on 4,487 larvae are listed in Table IV. Eighteen completed engorgement in 2 days, and 1 required 9 days, with the largest number (2,758) becoming fully engorged in 4 days. The average for the entire group was 3.9 days. There was no tendency to drop at any particular time of day, as in the case of some species. In some lots the majority dropped during

daylight hours and in others at night. Dropping simply built up to a single peak and fell away rapidly, the peak sometimes occurring at night and sometimes in the daytime. Larvae engorged satisfactorily on a muskrat, but not on a cotton-tail rabbit, although they have been found on both these hosts in nature. The average dimensions of 20 fully engorged larvae were 1.33 mm. from the tip of the hypostome to the

TABLE IV  
SEASONAL ENGORGEMENT OF LARVAE

Date Larvae Were Put On Host	Number of Larvae That Dropped Engorged on Specified Day Following Attachment								
	2	3	4	5	6	7	8	9	Total
<b>1938</b>									
July 9	....	28	182	27	4	..		.	241
9	....	4	190	83	10	1	2		290
26		43	515	78	12	1			649
26		81	423	37	1				542
26	.....	90	201	12	1				304
Sept. 8	..	25	430	127	4				586
19	.....	76	72	15	..	...		..	163
Dec. 6	..	20	32						52
16		161	104	17	1				283
<b>1939</b>									
Apr. 19	..		3	3	...	1			7
26		5	27	12	3			1	48
May 10		2		4					6
July 13		34	2	2					38
20		5	18	11	3				37
Aug. 10		21	108	6	1				136
14		293	285	23					601
24		65	48	3					116
Oct. 13			1	10	2				13
24		6							6
Nov. 10		6	1	5					12
10		3	2	1					6
Dec. 1	..		4	2	2				8
<b>1940</b>									
June 11		3	10	9	4				32
15			4	2	3				9
July 30			53	14	5		1		73
Aug. 27	18	167	37	4	2	1	...		229
Total	18	1,138	2,758	507	58	4	3	1	4,487

posterior extremity, 0.91 mm. across the body at the spiracles, and 0.69 mm. dorsoventrally at the thickest point. The maximum dimensions observed were 1.38 by 0.96 by 0.69 mm. and the minimum dimensions 1.29 by 0.87 by 0.66 mm.

*Larval Molting.*—Records on the molting of 533 engorged larvae, which were kept at a constant temperature of 80° F., are shown in Table V. The time required for molting ranged from 19 to 33 days.

In the case of individuals kept under outdoor conditions the time required was extended and the variation greatly increased, as shown by the records presented in Table VI. In the lots which became engorged and were placed outdoors at intervals from April to August, the molting period was as short as 26 days and as long as 79 days. It was of course greatly influenced by the temperature, but even in single lots the time required ranged from 31 to 46 days. In the case of larvae completing engorgement as late as September 15, the engorged larvae pass the winter satisfactorily and molt the following summer, the molting period in this case being extended to as much as 296 days. As larvae are commonly engorging at this time in nature, hibernation in the engorged as well as the unfed state must be considered a normal occurrence. As in the case of the incubation of eggs, the molting of larvae engorged

TABLE V

LARVAL MOLTING AT A CONTROLLED TEMPERATURE OF 80° F., 1938

Date of Dropping	No of Larvae	Number That Molted on Specified Day After Dropping																Total
		19	20	21	22	23	24	25	26	27	28	29	30	31	32	33		
Apr. 20	2																1	
May 7	1													1			1	
July 2	89								20	32	10	6					87	
2	364		63	101	118	65	8	3	1	2							361	
3	42	1	7	11	12	7	2										40	
4	12				1			1									2	
12	28			1	6	6	10	1	2								26	
14	27		2	3	3	1											9	
12	4					3											3	
15	10				1	2											3	
Total	579	1	72	116	141	84	22	22	23	34	10	6	0	1	0	1	533	

over a period of two months in April and May began in a period of about a week in early July. In 1939 molting began on July 2 from larvae engorged the same spring, but in 1940 only overwintered larvae molted before July 15.

*Nymphal Longevity.*—Records on nymphal longevity are presented in Table VI. The unengorged nymphs, like the unengorged larvae, survive the winter without injury, the majority living through the entire following summer. One lot engorged satisfactorily when 268 days old and another when 383 days old. Some lots died about a year after molting, whereas one lot lived for more than 3 years and a number lived 2 years.

*Nymphal Engorgement.*—The nymphs engorged fairly readily on meadow mice under experimental conditions, as many as 95 engorging on a single mouse at one time. Records on engorgement for 714 nymphs are given in Table VII. One individual completed engorgement in 2 days, the majority required 3 days, and other individuals dropped after 4 to 8 days. The average period for the group was 3.7 days. Nymphs

TABLE VI  
LARVAL MOLTING AND NYMPHAL LONGEVITY

Date of Dropping	Number of Larvae	Location	Date First Larva Molting	Date Last Larva Molting	Date Last Nymph Died	Molting Period, Days	Nymphal Longevity, Days
1938			1938	1938			
July 29	90	Outdoor breeding cage	Aug 1-31	Aug 1-31	Nov 20, 1940-Jan. 9, 1941		781-861
July 31	127	do	1-31	1-31	Aug 14-Sept 15, 1941		1,079-1,141
Sept. 13	50	do	Oct 14-Nov 17	Oct 14-Nov 17	Sept 18-Oct 15, 1940		672-732
1939			1939	1939			
Apr. 16	1	Outdoors uncovered	July 2	July 2	Sept. 18-Oct 15, 1940	77	444-471
July 27	1	Outdoors uncovered	July 7	July 7	do	71	439-466
May 1	27	Outdoor breeding cage	July 1	18	Nov. 20, 1940-Jan 9, 1941	65-79	491-534
May 12	12	Outdoors uncovered	13	18	July 18-Aug 15, 1940	72-78	366-394
May 29	2	Outdoors uncovered	5	9	Nov 20, 1940-Jan 9, 1941	54-58	500-554
July 16	34	Outdoor breeding cage	Aug 11	16	do	43-48	493-548
July 20	2	Outdoors uncovered	Aug 15	18	Aug 14-Sept. 15, 1941	30-33	727-762
July 22	9	do	Aug 23	23	July 18-Aug 15, 1940	34	330-358
July 23	12	do	Aug 29	26	Sept 18-Oct 15, 1940	29-35	389-422
July 24	26	Outdoor breeding cage	Aug 18	26	Aug 14-Sept. 15, 1941	26-34	719-750
July 25	11	Outdoors uncovered	Aug 20	23	Nov. 5-Dec. 9, 1941	27-30	805-842
Aug. 1	4	do	Aug 23	25	Aug. 15-Sept 18, 1940	26-31	356-395
Aug. 3	5	do	Aug 29	30	do	28-29	351-386
Aug. 14	108	Outdoor breeding cage	Sept 30	Sept 2	Oct. 6-Nov. 11, 1941	27-30	765-798
Aug. 17	21	Outdoors uncovered	Sept 11	17	June 11, 1940*	28-34	*268
Aug. 18	139	Outdoor breeding cage	Sept 12	18	Sept 15-Oct 6, 1941	30-36	728-755
Aug. 19	154	do	Sept 17	27	July 15-Aug 14, 1941	31-41	657-697
Aug. 20	285	Outdoors uncovered	Sept 18	Oct 2	June 17-July 15, 1941	31-46	624-667
Aug. 21	23	Outdoors uncovered	Sept 22	1	Oct. 18, 1940*	31-44	*383
Aug. 27	65	Outdoors uncovered	Sept 30	Sept 30	Jan. 9-Mar. 14, 1941	34-42	467-539
Aug. 28	48	Outdoor breeding cage	Oct 1	Oct 7	July 15-Aug 14, 1941	34-40	648-684
Sept. 15	21	Outdoors uncovered	Oct 1	1940	Jan. 19-Feb. 18, 1942	34-40	833-871†
Oct. 27	6	do	June 24-July 3	July 3	July 15-Aug 14, 1941	-296	
Nov. 15	6	Outdoor breeding cage	July 8	6	Sept. 18-Oct. 15, 1940	-253	
1940			1940	1940	Nov 5-Dec. 9, 1941	286-	74-113
May 11	1	Outdoors uncovered	15	July 15	Nov 20, 1940-Jan. 9, 1941	65	128-178
June 15	16	Outdoors uncovered	20	Aug 1	†	44-47	†
June 16	9	Outdoors uncovered	28	Aug 5	†	42-50	†

† Alive May 15, 1942

\* Engorged.

were engorged satisfactorily on a muskrat and a cotton-tail rabbit. There was no evidence of a tendency to drop at any particular time of day. The average dimensions of 20 fully engorged nymphs measured in the same manner as the larvae were 2.42 by 1.61 by 1.27 mm. The maximum dimensions observed were 2.70 by 1.71 by 1.44 mm. and the minimum dimensions 2.25 by 1.59 by 1.17 mm.

TABLE VII  
SEASONAL ENGORGEMENT OF NYMPHS

Date Nymphs Were Put on Host	Number of Nymphs	Number That Dropped Engorged on Specified Day Following Attachment							
		2	3	4	5	6	7	8	Total
1938									
July 26	35		12	9					21
Aug. 30	200	..	14	14	2	3			33
Sept. 12	35		1						1
12	105		41	7	2				50
17	430		3	9	8	1	3	1	25
15	200		11	12	3				26
16	70		13	8	4				25
19	90		16	9	4				29
Oct. 10	150		15	10	1				56
10	50		19	7	1				27
26	120			5	4				9
Nov. 4	90		1						1
21	50		2	5	3				10
Dec 16	200		48	43	4				95
23	150		36	24	7	8	1		76
1939									
Jan. 20	200		46	16	10				72
20	107		16		3				19
20	117		22	4	2	3	1		32
Apr. 11	48	1	9	2		1			13
17	50		15	3					18
May 2	60		1	7	20	1	2		31
10	38		1	16	2				19
20	40		1	4	3				8
1940									
June 11	95		1	2					3
15	15		6	6					12
15	25			3					3
Total	2,770	1	380	225	83	17	7	1	714

*Nymphal Molting.*—Typical records on nymphal molting are presented in Table VIII. Among nymphs kept at a constant temperature of 80° F. molting required from 31 to 48 days for nymphs producing males and from 35 to 48 days for nymphs producing females. In the case of nymphs kept outdoors under natural conditions the molting period varied greatly. Among lots exposed during the high temperatures of July and August it was reduced to as little as 25 days, whereas among those exposed during the colder weather of April it was extended to as



TABLE VIII  
NYMPHAL MOLTING AND ADULT LONGEVITY

Date of Dropping	Number of Nymphs	Location	Date First Nymph Molted	Date Last Nymph Molted	Date Last Adult Died	Molting Period, Days	Adult Longevity, Days
1938			1938	1938			
Mar. 28	2	Incubator	May 7	May 8		40-41	
Apr. 28	3	do	June 4	June 11		37-44	
Apr. 29	6	do	May 30	June 16		31-48	
May 1	4	do	June 11	June 18		41-48	
May 2	2	do	June 10	June 10		39	
May 6	6	do	June 9	June 16		34-41	
May 7	2	do	June 12	June 16		36-40	
May 8	2	do	June 9	June 14		32-37	
July 25	5	Outdoor breeding cage	Aug. 15-31	Aug. 1-31	Aug. 15-Sept. 18, 1940		715-779
Sept. 15	10	do	Oct. 14, 1939	Aug. 1-31	June 14-July 18, 1940		
23	0	Outdoors uncovered	July 7	July 24	Oct. 15-Nov. 20, 1940	287-304	449-502
1939							
Apr. 13	3	do	9	Aug. 2	Aug. 14-Sept. 15, 1941	87-89	765-799
Apr. 14	9	Outdoor breeding cage	15	Aug. 2	Aug. 14-Sept. 15, 1941	92-110	
17	5	Outdoors uncovered	10	July 17	Aug. 14-Sept. 15, 1941	84-90	759-798
20	15	Outdoor breeding cage	27	Aug. 7	Sept. 18-Oct. 15, 1940	98-109	408-446
26	5	Outdoors uncovered	7	July 27	Nov. 20, 1940-Jan. 9, 1941	72-92	482-552
27	7	Outdoor breeding cage	10	Aug. 8	Jan. 9-Mar. 14, 1941	74-93	530-613
May 7	10	do	26	Aug. 8	May 22-June 17, 1941	80-94	653-692
May 7	10	Outdoors uncovered	25	Aug. 8	June 11, 1940†	79-98	†802
12	3	do	11	July 19	April 12-May 22, 1941	63-68	633-681
19	3	Outdoor breeding cage	26	Aug. 2	Jan. 9-Mar. 14, 1941	68-71	530-597
24	4	Outdoors uncovered	5	Aug. 2	Jan. 9-Mar. 14, 1941	68-71	530-597
25	3	Outdoor breeding cage	18	Aug. 2	Dec. 1940-Jan. 9, 1942	46-52	837-918
June 16	1	Outdoors uncovered	Aug. 18	Aug. 18	Nov. 20, 1940-Jan. 9, 1941	63	460-510
July 13	2	Outdoor breeding cage	17	July 17	Sept. 22, 1939-Feb. 7, 1940	32	36-174
15	2	do	15	July 16	Sept. 22, 1939-Feb. 7, 1940	34	36-174
19	1	do	23	July 23	April 12-May 22, 1941	31-32	36-174
20	3	Outdoors uncovered	16	Aug. 1	Aug. 12-May 22, 1941	35	508-638
21	2	Outdoor breeding cage	19	Sept. 2	Aug. 15-Sept. 18, 1940	27-32	380-390
21	2	Outdoor breeding cage	28	Oct. 1	Aug. 14-Sept. 15, 1941	29-43	712-758
Aug. 3	3	Outdoors uncovered	1	Oct. 5	Jan. 17-July 15, 1941	25-42	642-687
Aug. 24	3	do	1	Oct. 5	Jan. 19-Feb. 18, 1942	38-42	837-871
Sept. 14	1	do	1	July 22	* Feb. 18-Mar. 17, 1942	312	* 578-602
15	2	do	22	July 22	* Feb. 18-Mar. 17, 1942	312-314	* 578-602
16	1	Outdoor breeding cage	Aug. 1	Aug. 1	* Feb. 18-Mar. 17, 1942	320	* 578-602
1940							
May 11	1	Outdoors uncovered	July 26	July 26	* Sept. 18-Oct. 15, 1940	76	* 48-78
June 18	2	Outdoor breeding cage	28	Aug. 1	Sept. 18-Oct. 15, 1940	44-47	48-78
June 18	6	Outdoors uncovered	28	Aug. 6	Aug. 14-Sept. 15, 1941	40-49	373-414
19	9	Outdoor breeding cage	Aug. 2	Aug. 14	Aug. 14-Sept. 15, 1941	44-56	373-414

\* Alive May 15, 1942.

† Engorged.

much as 110 days. Four nymphs that dropped in September, 1939, survived the winter in the engorged state and molted the following summer, giving molting periods of 312, 312, 314, and 320 days. In 1938, when the fall months were warmer than in 1939, 10 nymphs that dropped September 15 began molting the same fall, whereas 9 that dropped September 23 did not molt until the following summer, after 287 to 304 days. Since nymphs are active in nature at this time, it is evident that hibernation in the engorged condition is a normal occurrence, as in the case of females and larvae.

The molting period was somewhat shorter in the case of nymphs producing males than in the case of nymphs producing females when exposed to identical conditions. Of the 17 lots producing adults of both sexes, males molted first in 15 lots, and all males molted before any females in 12 lots. There was also a significant difference in the proportion of adults of each sex produced. Of the 130 nymphs under discussion 77 produced males (59.2 per cent) and 53 molted to females.

The earliest molting under outdoor conditions in 1939 was on July 5, from nymphs dropping on May 24, with overwintered nymphs molting shortly thereafter. Molting continued until October 5. The earliest molting in 1940 occurred on July 22, from overwintered nymphs, but no early spring records had been started.

*Adult Longevity.*—Records on adult longevity are shown in Table VIII. Both sexes survived the winter readily, and females engorged and oviposited when almost a year old. Practically all lots lived through parts of two seasons of activity, and many lots lived through parts of three seasons of activity, showing a maximum longevity of 877 to 924 days.

*Mating Habits.*—The adults of the mouse tick do not mate on the host, but on the ground before the females have attached. In rearing tubes mating was often observed less than 24 hours after the females had molted. As males had usually molted some days before the females appeared, the shortest possible interval between molting and mating is not known for that sex. Sometimes mating pairs parted within a few hours, but sometimes they remained paired for days. One pair was observed to mate in September 1939 and again in May 1940. The males never feed and, except for the one specimen reported in the original description of this species, have never been found on a mouse or other animal. Even when confined on mice, males consistently refused to attach.

When females had been kept separated from males, so that there had been no opportunity for them to mate, they refused to attach to mice even when confined on them, but females which had mated attached and engorged readily.

*Adult Engorgement.*—Records on engorgement for 55 females are shown in Table IX. Two individuals completed feeding in 4 days and one individual required 8 days, whereas all the others dropped after 5 or 6 days. The average period was 5.4 days. Although females have been found on cotton-tail rabbits in nature, one attempt to engorge them experimentally on this host was unsuccessful. The average dimensions of 47 fully engorged females, measured in the same manner

as the larvae, were 7.2 by 5.2 by 4.3 mm. The largest female observed measured 8.2 by 6.0 by 5.5 mm., and the smallest 5.9 by 4.3 by 3.9 mm.

*Seasonal Activity.*—Studies on the seasonal activity of the various stages in connection with the developmental cycle were based on data of two types. Engorged ticks in all stages were exposed to outdoor conditions using the methods previously described. As specimens were started at intervals throughout the season of activity, it is possible to

TABLE IX  
SEASONAL ENGORGEMENT OF FEMALES

Date Females Were Put on Host	Number of Females	Number That Dropped Engorged on Specified Day Following Attachment					
		4	5	6	7	8	Total
1938							
May 29	2			1			1
July 9	5			2			2
Sept. 19	4		2				2
Oct. 14	9		3	1			4
26	8		2				2
Nov. 4	6		1				1
Dec. 9	8		3				3
10	15		4	1		1	6
20	5			2			2
1939							
Mar. 17	9	1					1
Apr. 10	4	1	1				2
26	7		3				3
May 10	8		2	3			5
July 13	8			2			2
19	6			1			1
20	4			1			1
27	6		3				3
27	10		3				3
Aug. 10	7			2			2
14	10			2			2
Sept. 7	9			1			1
1940							
Mar. 21	3			2			2
June 11	3		3				3
July 19	1		1				1
Total	157	2	31	21	0	1	55

determine from these records exactly when hatching or molting would occur from ticks dropping in any part of the season. These records have been listed in the foregoing tables. Data of a second type were obtained by collecting all stages from wild mice captured in nature throughout the season of tick activity. As mentioned previously, about 2,500 mice were examined, collections being made every month from August 1937 to October 1941 at four localities and occasionally in a number of additional areas. The collections in one locality, typical of all, are presented in Table X. By a comparison of these two types

of records it should be possible to determine which developmental potentialities are normally realized.

*Larval Activity.*—It will be noted in Table X that in all three years, 1938, 1939, and 1940, larvae were scarce until July at Edgartown, the area where this species was most abundant. This might mean either that few larvae were in the area or that larvae were present in numbers but did not become active before July. However, it will be noted in Table III that the earliest hatching under outdoor conditions, from females that engorged at the beginning of their season of activity, occurred on July 7 in 1939 and on July 20 in 1940. About July 8, 1940, hatching began from eggs deposited by females that had dropped the

TABLE X

SEASONAL ABUNDANCE OF *Ixodes muris* AT EDGARTOWN, MASS., AS INDICATED BY THE TOTAL NUMBER OF TICKS TAKEN ON MICE, 40 MOUSE TRAPS HAVING BEEN SET ONCE EACH MONTH

Month	Number of Mice and Ticks Collected Each Month in Specified Year											
	Mice			Larval Ticks			Nymphal Ticks			Adult Ticks		
	1938	1939	1940	1938	1939	1940	1938	1939	1940	1938	1939	1940
Jan	11	10	8	.	.	.	.	.	.	.	.	.
Feb	8	8	10	.	.	.	.	.	.	.	.	.
Mar	4	9	10	.	.	.	.	.	.	3	.	.
Apr	5	9	7	.	1	.	6	15	1	.	1	.
May	14	7	12	.	.	1	6	2	3	2	.	2
June	14	9	21	.	.	.	.	8	2	.	1	2
July	21	10	19	14	3	23	4	1	7	.	.	.
Aug	20	18	20	40	40	94	.	4	5	.	1	.
Sept	26	22	19	23	52	31	.	3	2	.	4	.
Oct	15	11	17	.	5	3	1	.	.	.	.	.
Nov	11	14	26	.	....	3	.	.	.	.	.	.
Dec	15	4	7	..	.	.	.	.	.	.	.	.

previous fall. Within 17 days after the earliest hatching, the eggs from all the females engorged throughout April and May began to hatch, and, within the same fortnight, hatching began among the eggs of all females engorged after August 15 of the preceding year. Therefore, a large number of eggs hatch immediately before the sudden July and August peak of larval abundance, an indication that the small number of ticks found previously, and the large number found later, are due to an absence of overwintering larvae and the midsummer hatching, respectively. Also the records for 1939 in Table III show that no hatching began after September 13 from females dropped August 1. Females dropped August 16 and later did not oviposit until the following spring. In the same year larvae were active until mid-October, giving the majority time to engorge the same fall and accounting for the small carry-over to the next spring.

By comparison of the two types of records one finds that in nature there is little larval activity before late July, as few flat larvae survive

the winter. As soon as hatching occurs, either from females engorged the same spring or from those dropped the previous fall, the newly hatched larvae become active, and activity continues until October or November, when the great majority of larvae have become engorged. The few larvae that do not have an opportunity to feed survive the winter readily and engorge the following spring. All the foregoing, of course, applies to areas in which mice are plentiful. If mice were scarce in an area, a larger proportion of larvae might fail to find hosts and survive from one season to the next.

The seasonal abundance in a second area, where the species was less numerous, was less regular but conformed in general with that just discussed, an indication that this behavior is typical of other areas as well.

*Nymphal Activity.*—It will be noted that in all years the seasonal abundance of nymphs in the Edgartown area was irregular, rising and falling several times. In order to interpret this fluctuation, one must consider the seasonal abundance of larvae and the records of larval molting under outdoor conditions (Table VI). In all years nymphs were very active at the beginning of the season. As the spring of 1938 was warmer than that of 1939 and the spring of 1940 colder than either, nymphs reached a peak of activity in March, April, and May of those years, respectively. As no molting occurred this early in the season from larvae dropped at any time, these nymphs evidently hibernated in that stage. The column of larval abundance shows that the majority of larvae drop in August and September. Larvae dropping in August would not molt until September or October, when few nymphs are active, an indication that the great majority would carry over to form this spring peak. Possibly some larvae engorged in July molt early enough to form a peak in August, as indicated in 1939, although this does not appear to have happened in 1938 or 1940. The larger number of larvae engorging in September may molt the same fall, as some did in 1938, or may survive the winter, as they did in 1939, molting the following July in time to cause the nymphal peak noted in that month.

The seasonal abundance of nymphs in a second area agrees in general with that in the first.

*Adult Activity.*—Adults occur in such small numbers that a listing of the seasonal abundance reveals little. They have been found on mice every month from March through September. Of collections from all areas, there were 27 in which only 1 female was taken, 7 in which 2 females were taken, 3 in which 3 females were taken, and 2 in which 4 were taken. As no nymphs molted before July in nature (Table VIII), some females obviously passed the winter in the adult stage, whereas others probably engorged the same summer in which they molted.

# STUDIES ON *TRIBOLIUM CONFUSUM* DUVAL

## III. ABNORMALITIES PRODUCED IN *TRIBOLIUM CONFUSUM* DUVAL BY EXPOSURE TO ACETIC AND HYDROCHLORIC ACIDS

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Roth and Howland (1941) found that various abnormalities could be produced in *Tribolium confusum* by subjecting different developmental stages of this beetle to both the vapors and crystals of the odoriferous substance given off by the adults. The most interesting deformities were obtained by direct application of the crystals to the leg region of last instar larvae. Affected larvae gave rise to adults which possessed abnormal legs. These varied from mere undifferentiated outgrowths to complete duplications and triplications of various parts. It was suggested at that time that these abnormalities may have resulted from a regeneration of the imaginal discs which were injured by the odoriferous substance. Duplications and triplications are supposedly not uncommon abnormalities resulting from regeneration. If these deformities are cases of regeneration due to injury, then it should be possible to injure the discs with other chemicals and so obtain similar monstrosities.

Although the original purpose of the following experiments was to determine if duplications and triplications could be obtained by the application of various chemicals to the leg region of larvae, various stages of *Tribolium* were also subjected to the vapors of acids to compare abnormalities, if any, with those produced with the vapors of the odoriferous substance.<sup>2</sup>

### MATERIALS AND METHODS

Experimental and control animals were reared as described by Roth and Howland (1941). The developmental stages used were sifted from the flour when needed. All animals were reared at 29° C.

Various chemical agents were tried. These were chosen for no specific reason except that they were present in the laboratory and no doubt would be more or less injurious to the insect. They included M/100 KCN in spring water, 0.01% strychnine sulphate, acetone, glacial acetic acid, and HCl. From preliminary experiments it was

<sup>1</sup>This study was completed in the Department of Entomology, Ohio State University, Columbus, Ohio.

<sup>2</sup>Since this paper was written the odoriferous substance given off by *Tribolium* has been identified as ethylquinone (P. Alexander and D. H. R. Barton, *Biochemical Journal* Vol. 37: 463-465: 1943). The development and structure of the glands producing this substance has also been described (L. M. Roth, *Ann. Ent. Soc. Amer.*, 36: 397-424: 1943).

found that the first three substances gave very few abnormalities while acetic and hydrochloric acids gave the greatest number and most drastic effects. Therefore the effects of these two acids were studied in some detail.

The chemicals were applied by means of a micropipette attached to an injection circuit similar to that on a Chambers micromanipulator. This was set up on a binocular dissecting microscope. A drop or drops of acid generally large enough to cover the leg region of a larva was applied to each experimental animal. Larvae were etherized during treatment (controls were etherized for the same length of time as experimentals).

Larvae were also treated with crystals of the odoriferous substance to check the previous results obtained. The technique described by Roth and Howland for collecting and applying the crystals was used in the present work.

Various stages of *Tribolium* were subjected to the vapors of concentrated hydrochloric and acetic acids. Preliminary experiments with the vapors of HCl showed that all stages (last instar, prepupae, and pupae) were killed with a five minute exposure and that after a two minute exposure, the percentage of mortality was high and consequently the percentage of abnormality low. Therefore the various stages were exposed to the vapors of acetic acid only. The apparatus described by Roth and Howland, for gassing, was used with a slight modification. A train of 14 vials (7 controls and 7 experimentals),  $\frac{7}{8}$ " x  $3\frac{3}{4}$ ", was devised (see Roth and Howland, 1941, fig. 2).

After treatment all animals were placed in syracuse dishes and reared at 29° C. Adults were examined in alcohol, in a white porcelain evaporating dish, under a binocular dissecting microscope; thus any abnormalities were easily detected. Abnormal appendages were dissected away, dehydrated, cleared in xylol and mounted unstained in balsam. All drawings were outlined with the aid of camera lucida.

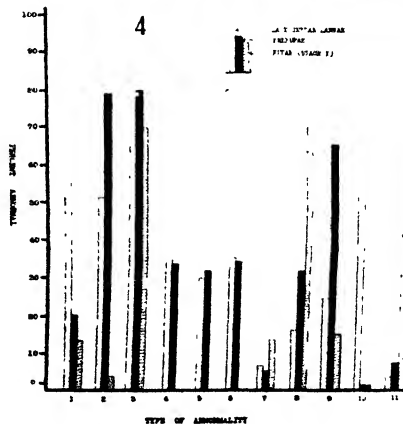
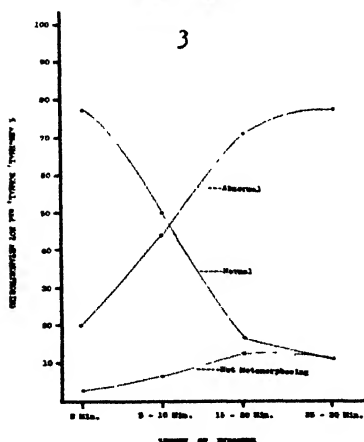
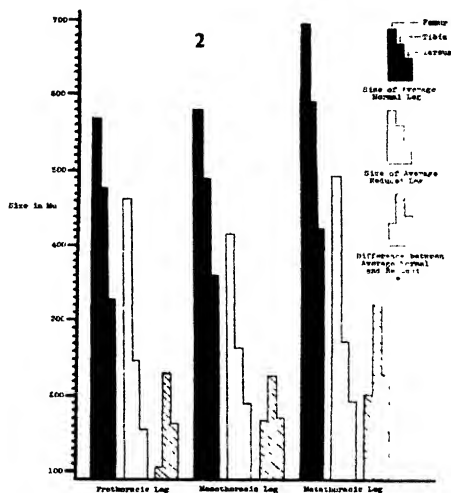
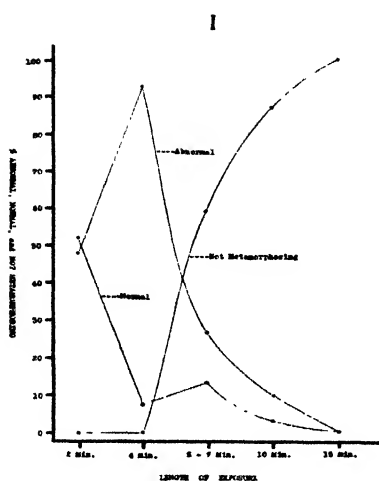
## EXPERIMENTAL RESULTS

### EFFECT OF VAPORS

Various stages of *Tribolium*, including immature larvae, last instar larvae, prepupae, and Stage I and II pupae, were subjected to the vapors of 30 cc. of glacial acetic acid for 15 minutes.

*Affected Immature and Last Instar Larvae.*—Immature and last instar larvae went into vigorous contractions and contortions and were inactivated after being subjected to acetic acid vapors for 15 minutes. None of these recovered and some became blackened entirely or in part while others were laterally compressed and distended.

Since a 15 minute exposure was lethal for larvae, last instar larvae were subjected to acetic acid vapors for various shorter lengths of time. The results are shown in graph 1. The 4 minute exposure was the optimum for producing abnormalities, since there was no mortality and a high percentage of abnormality. There was a high mortality beginning at the 5 minute exposure and this increased steadily until a mortality of 100% was obtained with a 15 minute exposure. The



GRAPH 1. Graph showing the percentage of abnormal, normal, and those not metamorphosing of last instar larvae subjected to the vapors of glacial acetic acid for various lengths of time. Min.—minutes.

GRAPH 2. A comparison of the sizes of normal and reduced appendages. (Data taken from table 1.)

GRAPH 3. Graph showing the increase in the percentage of abnormal, and the decrease in the percentage of normal adults, with an increase in the length of exposure of prepupae to the vapors of glacial acetic acid. Min.—minutes.

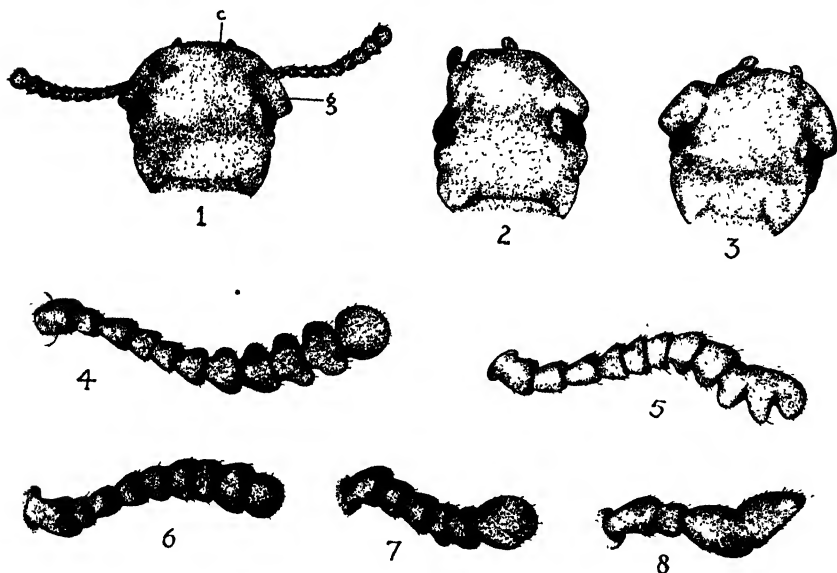
GRAPH 4. Graph showing the frequency of the various abnormalities obtained after subjecting different stages of *Tribolium* to the vapors of glacial acetic acid for various lengths of time. 1. Individuals with abnormal antennae. 2. Individuals with abnormal mouthparts. 3. Individuals with abnormal legs. 4. Abnormal prothoracic legs. 5. Abnormal mesothoracic legs. 6. Abnormal metathoracic legs. 7. Appendages entirely missing or with coxa and trochanter present only or absent in part. 8. Appendages with abnormal femur and (or) tibia; malformed; tibia partly or entirely missing. 9. Appendages with abnormal tarsi; malformed; segments fused; no claws; tarsus missing entirely. 10. Appendages entirely or partly reduced and malformed. 11. Individuals with abnormal elytra.



\* Data taken from the measurements of the legs of 10 adults. Tarsal claws are not included in the measurement of tarsi.  
† Missing from the appendage. These are not included in computing the average reduction.

sudden decrease in the percentage of abnormal individuals with the longer exposures (5 to 15 minutes) was due to this great increase in mortality.

A total of 66 abnormal individuals were obtained in these experiments. This number included a high percentage of leg (65.1%), antennal (56%), and mouthpart (51.5%) deformities. The different legs were about equally affected (graph 4, Nos. 4, 5, and 6). In a total of 102 abnormal legs, the most common leg deformity was a reduction in size (50.9%) and this was usually accompanied by malformation (figs. 24-28; cf. figs. 14-16).



FIGURES 1-8

Head and antennal abnormalities in *Tribolium confusum*. Figure 1. Head of a normal adult; *c*—clypeus, *g*—gena. 2 and 3. Heads of abnormal adults resulting from gassed Stage I pupae, showing abnormal gena and clypeus; the antennae, which are not figured, are normal. 4. A normal adult antenna. 5-8. Abnormal adult antennae resulting from gassed last instar larvae, showing reduction in number, fusion, and malformation of the segments. Magnification of figures 1-3, about 20 $\times$ ; of figures 4-8, about 38 $\times$ .

This remarkable reduction is strikingly shown in both table I and graph 2. Although there generally was not a uniform reduction of all parts, occasionally some legs were reduced proportionately so that they looked exactly like normal appendages except for size. Frequently the coxa and trochanter were of normal size while the remaining parts were reduced. Abnormal tarsi was the next most frequent leg deformity (24.5%). These had fused segments, lacked segments, or were, occasionally, abnormally melanized. Two adults showed an increase in the number of tarsal segments (one right mesothoracic leg

and one right prothoracic leg had six segments instead of the normal five; fig. 22). In 17.6% the femur or tibia was abnormal, or the leg lacked the tibia partly or entirely; 6.8% lacked entire appendages or possessed only a coxa or trochanter.

Antennal segments were either fused, missing, or malformed (figs. 5-8). A few were not normally melanized. Of the mouthpart abnormalities, the labium and maxillae were often missing or reduced. Only 3% of the abnormal adults had an abnormal gena or clypeus, and 4.5% had deformed elytra (balloon-like swellings; partly missing; unmelanized).

*Affected Prepupae.*—Affected prepupae produced pupae with various parts of the appendages blackened, the degree of blackening varying with different abnormal individuals (see Roth and Howland, 1941, pl. II, figs. 10, 12). Pupae were also formed which lacked parts of the legs and mouthparts; some of these had a black or amber colored blob at the end of the remaining stump of the appendage, while others lacked this blob. The adults resulting from these pupae lacked the blackened pupal structures which were left behind in the moulted skin (see Roth and Howland, pl. II, fig. 13). Those parts that were missing in abnormal pupae were also missing in the adult.

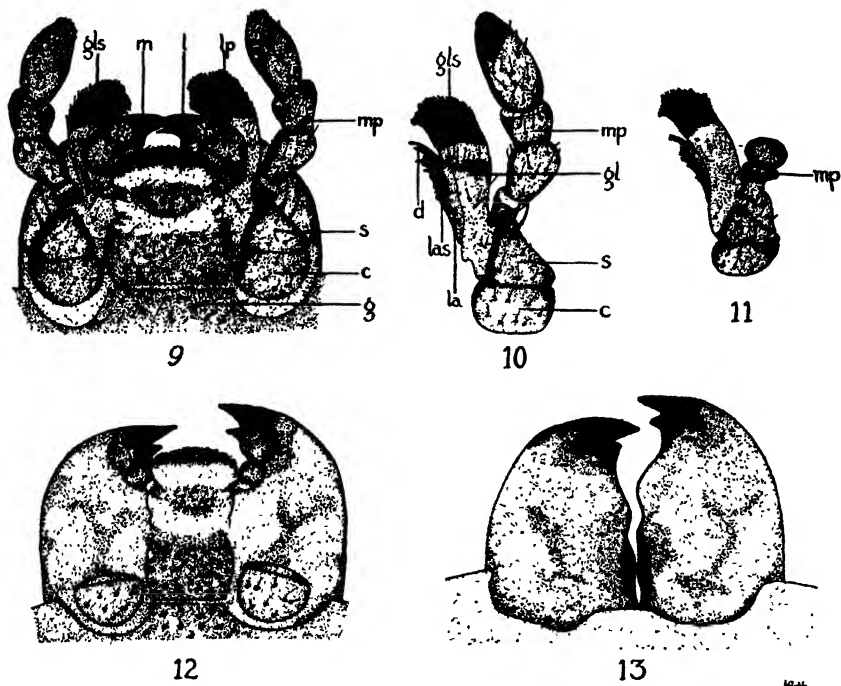
Eighty-three abnormal adults were obtained in these experiments. An analysis of the different types of abnormalities showed that the mouthparts (86.7%) and legs (78.3%) were more frequently abnormal than the antennae (20.4%); most individuals had both mouthpart and leg deformities. The pro-, meso-, and metathoracic legs were about equally affected (graph 4, Nos. 4, 5, 6).

Of 250 abnormal legs, tarsal abnormalities were more frequent than any other type (64%), the next abnormality in order of frequency being femur and tibial deformities (30.8%). Of the tarsal abnormalities, the absence of claws or lack of some segments were the most common (figs. 20, 21); the most frequent femur and tibial deformity was the femur having only part of the tibia attached (figs. 17-19). The absence of the entire appendage occurred only occasionally (5.2%).

Antennal deformities consisted of a fusion, lack, or reduction in size of some of the segments (figs. 5-8). Maxillary palps were frequently absent entirely or their segments were reduced in size (figs. 11, 12). An occasional but drastic mouthpart deformity was the absence of the maxillae and labium, in which case the mandibles (normally partly hidden by the labium and maxillae, fig. 9) were fully exposed and clearly seen from the ventral side (fig. 13). The brush-like galarastrea and lacinarastrea were also sometimes reduced. The labial palps were also affected while mandibular deformities were rare.

A number of individuals had difficulty in moulting their pupal skins and the exuviae would often cling to the elytra and abdomen. The resulting elytra were generally diverged and failed to harden and melanize normally. Some pupae failed to moult completely but continued to develop; in these, melanization and sclerotization continued and individuals were often obtained who possessed melanized areas like the adult (the head, thorax, antennae, legs, etc., a dark reddish brown), but the animals were still enclosed by their pupal skins.

Prepupae were subjected to the vapors of acetic acid for various lengths of time. There was an increase in the percentage of abnormal individuals and a corresponding decrease in the percentage of normal adults with an increase in the length of exposure. There was also a slight increase in mortality. This is shown in graph 3. An analysis of the various abnormalities found confirmed the previous results



FIGURES 9-13

Mouthpart abnormalities in *Tribolium confusum*. Figure 9. Mouthparts of a normal adult, ventral view (labrum not shown). 10. Maxilla of a normal adult. 11-13. Mouthparts of abnormal adults resulting from prepupae exposed to the vapors of acetic acid: 11, abnormal maxilla (all parts are reduced and the palp is malformed and composed of only two segments); 12, abnormal maxillae (only the cardo and a small portion of the stipes remain); 13, labium and maxillae entirely missing, exposing the mandibles. Figures 12 and 13 are ventral views; the labrum is present but is not shown. Abbreviations: *c*—cardo, *d*—distal hooks, *g*—gula, *gl*—galea, *gls*—galarastr, *l*—labium, *las*—lacinia, *la*—lacinia, *lp*—labial palps, *m*—mandibles, *mp*—maxillary palps, *s*—stipes. Magnification, about 50 $\times$ .

obtained by a 15 minute exposure of prepupae to the vapors. The increase in length of exposure generally does not increase the degree of abnormality but merely the percentage of abnormal adults. Prepupae exposed for 2, 5, and 10 minutes gave essentially similar abnormalities as those developing from longer exposed prepupae.

We can conclude from graph 4 that the adults resulting from prepupae affected by acetic acid vapors have about the same percentage of mouthpart and leg deformities and these are much more frequent than antennal abnormalities. Any pair of the legs (pro-, meso-, or metathoracic) as regards to frequency, may be equally affected; tarsal abnormalities were most frequent with femur and tibial deformities next.

In the antennal deformities, segments 9 and 10 were most frequently fused; segments 4 and 5, 6 and 7, and 10 and 11 were also affected. Occasionally antennae lacked some segments, the eleventh segment was reduced in size, or the antennal club was abnormal.

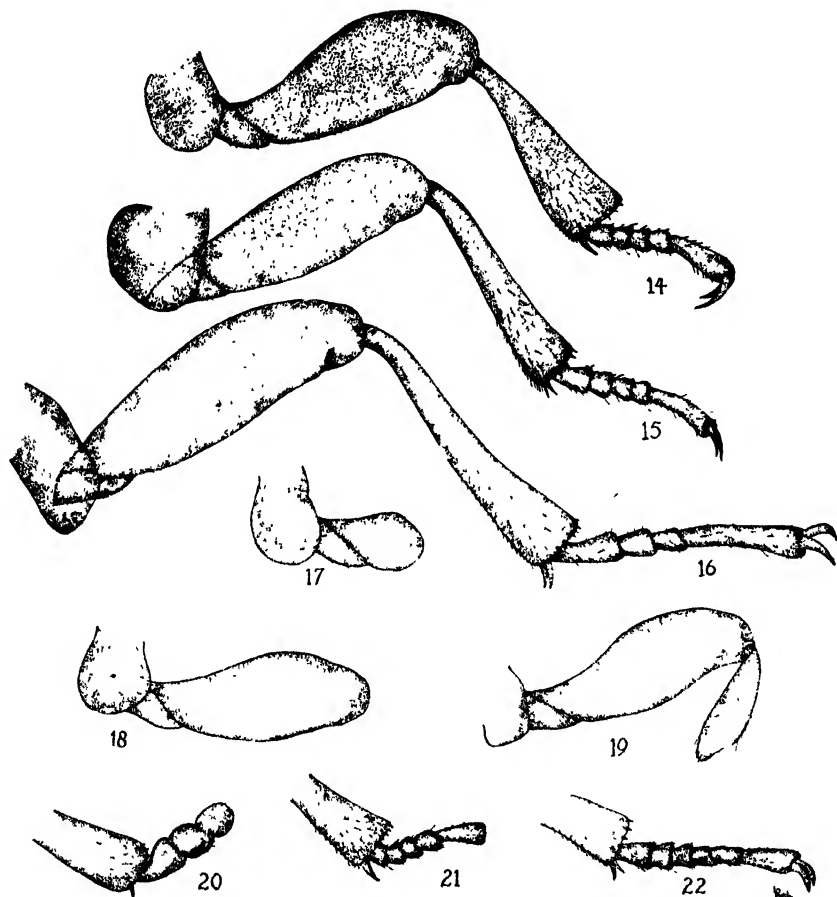
Since the prepupal stage may last about two days or a little more, prepupae of various ages were subjected to the vapors of acetic acid for ten minutes. Last instar larvae are very active, but just before entering the prepupal stage they become sluggish and move very little. However, although they cannot crawl about, they move their legs and twist their abdomens. Last instar larvae may be isolated and observed daily. When they become sluggish they may be considered as going into the prepupal stage and timed from that point on. The various ages used were: very early prepupae (still slightly active), about one day old, one day plus, and more than two-day old prepupae.

Although only 10 very early prepupae were treated, it is significant that all 10 produced approximately the same type of abnormalities. All of these prepupae moulted into pupae which lacked various parts of the legs, antennae, and mouthparts. Only two of the pupae possessed blackened appendages. The resulting adults lacked the parts missing in the pupae. In 59 abnormal legs only 15.2% had tarsal abnormalities (figs. 20, 21), 60.8% abnormalities of the femur and tibia (figs. 17-19), and 23.7% had the appendages entirely missing, or had only the coxa and trochanter present. All 10 individuals possessed abnormal mouthparts and antennae. The antennae generally lacked segments, or had some segments fused (figs. 5-8). The abnormal mouthparts were of the most drastic type where the maxillae and labium were entirely missing, thus fully exposing the mandibles (fig. 13) which in a few cases were also malformed (twisted).

Eleven of the 19 older prepupae (about one day and one day plus) that were treated, and 17 of the 20 abnormal prepupae, produced pupae with blackened appendages. These blackened structures were missing in the adults. Antennal abnormalities were infrequent (10.5%), while mouthpart deformities were common (84.6%) and more or less the same, generally affecting the maxillary palps which were usually malformed, reduced, or partly missing (figs. 11, 12). Of the leg abnormalities, tarsal deformities (58.5%) (figs. 20, 21) were more frequent than femur and tibial abnormalities (35%) (figs. 17-19), which in turn outnumbered the cases in which the appendages were entirely missing (6.5%). In the abnormal adults resulting from more-than-2-day-old prepupae, there was apparently little difference from the two preceding stages except that there was a decrease in the percentage of individuals with abnormal mouthparts (44.4%) (maxillary palp type).

Thus it is probable that the age of the treated prepupae determines the type and the degree of abnormality produced in the adult. Very

young prepupae, when treated, produced pupae lacking parts of appendages (few individuals blackened) and adults lacking parts of the femur or tibia, or lacking the entire appendage. Antennal segments were fused or missing, and maxillae and labium were also missing.



FIGURES 14-22

Normal and abnormal legs in *Tribolium confusum*. Figure 14. Normal adult prothoracic leg. 15. Normal adult mesothoracic leg. 16. Normal adult metathoracic leg. 17-21. Abnormal adult legs resulting from prepupae subjected to the vapors of acetic acid. 17. Abnormal prothoracic leg; part of the femur and the entire tibia and tarsus are missing. 18. Abnormal prothoracic leg; the tibia and tarsus are missing. 19. Abnormal prothoracic leg; part of the tibia and the entire tarsus are missing. 20. Abnormal mesothoracic leg; one tarsal segment and the claws are missing; the other segments are malformed and partly fused. 21. Abnormal prothoracic leg; tarsal claws are absent. 22. Abnormal mesothoracic leg resulting from a last instar larva subjected to the vapors of acetic acid; there are six tarsal segments instead of the normal five. In figs. 20-22 the proximal portion of the leg is normal and is not figured. Magnification, about 35 $\times$ .

Older prepupae when treated produced pupae with parts of appendages blackened. These necrotic areas (see Roth and Howland, 1941, p. 161), were missing in the adult. Tarsal abnormalities were more frequent than other types. There were few antennal deformities (as compared to those of legs and mouthparts), and mouthpart abnormalities were generally restricted to the maxillae.

This would explain the previous results and percentages obtained from treated prepupae. All experimental animals were originally sifted out from flour and the approximate ages of these prepupae were not known. It is very probable that most of the treated forms were about one day or more old. This would account for the low percentage of antennal deformities and also for the fact that so few of the abnormal mouthparts lacked the maxillae and labium entirely, and that most of the leg abnormalities were of the tarsal type.

*Affected Pupae.*—Pupae were separated into four different stages according to changes in pigmentation:

*Stage I.*—Pupa completely white or light tan; eye pigmentation, just at pupation, very light and only a few individual facets distinguishable. At the end of Stage I individual facets are clearly seen but the interfacet spaces are still more or less white. (About 1-5 days after pupation at 29° C.)

*Stage II.*—Pupa light tan; eye pigmentation black. Although individual facets are discernible, the interfacet spaces have also become darker in pigmentation. (About 6 days after pupation.)

*Stage III.*—Eyes black and tips of mandibles darkly pigmented; tarsal claws brown and easily discernible; tarsal segmentation absent or very indistinct; antennae and remaining portion of the legs not yet pigmented. (About 7 days after pupation.)

*Stage IV.*—Eyes and tips of mandibles black; genae dark brown; antennae, tibiae and tarsi light or dark brown; tarsal segmentation clearly visible and the claws moving freely within the pupal skin. (About 7 or 8 days after pupation.)

Stage III and IV are of very short duration. The entire pupal period at 29° C. (humidity uncontrolled) lasts about 7 or 8 days.

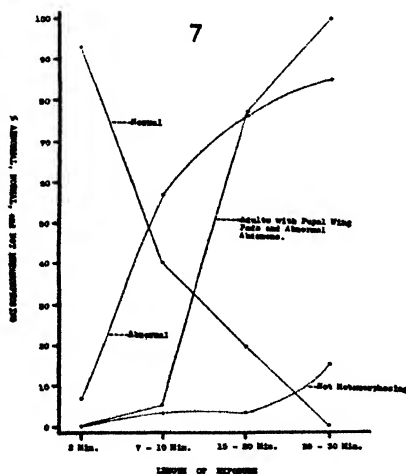
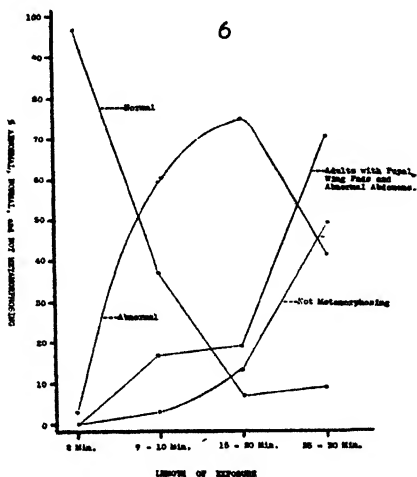
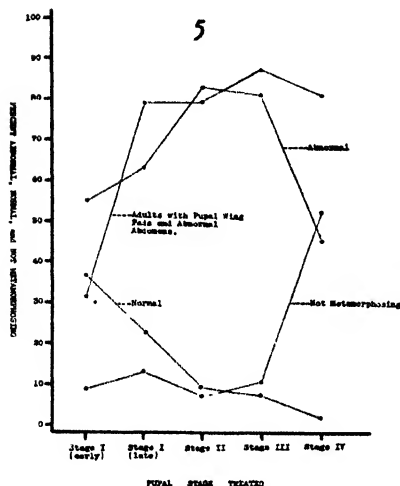
Various pupal stages were exposed to the vapors of glacial acetic acid for 15 minutes. The results are shown in graph 5. With a 15 minute exposure, apparently, early Stage I pupae (pupae shortly after pupation) give the lowest percentage abnormality and the highest percentage normal individuals. The percentage of abnormal beetles increases with Stages I (late), II, and III, and suddenly falls with individuals from Stage IV. This drop is undoubtedly due to the sudden increase in mortality obtained from treated Stage IV pupae (graph 5). There is a slight fluctuation in mortality from Stages I-III. The percentage of normal beetles decreases with the increase in age of treated pupae.

It is also interesting to note that the number of abnormal beetles possessing pupal wing pads and abnormal abdomens was lowest from Stage I pupae (early) and high in all other treated stages.

The various types of abnormalities obtained from the different pupal stages may be listed as follows:

Abnormalities obtained from Stage I pupae (see graph 4):

1. Abnormal elytra; elytra diverging, parts missing, unmelanized and unsclerotized (figs. 30-34).
2. Abnormal heads; parts of the genae or clypeus missing (figs. 2, 3).
3. Various parts of the legs missing (figs. 17-19). These had remained pupal and were left behind with the exuviae.



GRAPH 5. A comparison of the percentage of abnormal, normal, and those not metamorphosing of the different pupal stages subjected to the vapors of acetic acid for 15 minutes.

GRAPH 6. Graph showing the results obtained by exposing Stage I pupae to the vapors of acetic acid for various lengths of time. *Min.*—minutes.

GRAPH 7. Graph showing the results obtained by exposing Stage III pupae to the vapors of acetic acid for various lengths of time. *Min.*—minutes.



4. Abnormal antennae; some of the segments may be fused or missing.
5. Adults with pupal wing pads and abdomens. Many of these also possessed pupal appendages. Since they generally fail to moult these pupal structures usually remained attached to the adult.

*Abnormalities obtained from Stage II pupae:*

1. Elytral abnormalities; diverging or wrinkled (fig. 33).
2. Various parts of the legs missing or not normally melanized.
3. Antennal segments may be fused or unmelanized.
4. Individuals with pupal wing pads and abdomens; the abdominal sclerites may become lightly pigmented or may be melanized in isolated regions only (parts of the sclerites pigmented only; remaining portions colorless). The appendages may remain partly or entirely pupal.

*Abnormalities obtained from Stage III pupae:*

1. Elytra abnormal; diverging or with balloon-like swellings at their bases (figs. 33, 35). These swollen areas are generally unmelanized and appear pupal.
2. In those individuals that moult, various parts of the legs are missing or are not melanized normally.
3. Same as number 4 under Stage II.

*Abnormalities obtained from Stage IV pupae:*

1. Individuals with pupal wing pads and abdomens (generally fail to moult normally). The elytra may become dark brown but still remain wrinkled and pupal-like in character. Abdominal sclerites may become pigmented in certain areas only or they may also become normally pigmented. Various parts of the legs are also abnormally pigmented (very light as compared to the normally pigmented structures on the same animal).
2. In individuals that moult normally, various parts of the appendages may be abnormally pigmented.

It will be noted that only from early Stage I pupae were elytra obtained with parts missing. Older pupae produced adults with elytra that were diverging or possessed balloon-like swellings. Also, early Stage I gave more antennal abnormalities than any of the others and was the only stage (of treated pupae) that produced abnormal adult heads.

To determine if the length of exposure had any effect on the type of abnormality produced, Stage I pupae were subjected to the acid vapors for various lengths of time. The results are shown in graph 6. The percentage of normal individuals decreases steadily with an increase in the length of exposure, while the percentage of abnormal adults increases up to the 15-20 minute exposure, and suddenly drops at the 25-30 minute exposure, due to the high increase in mortality. Further tests showed that pupae about one day old give a high percentage of mortality when subjected to the vapors for 30 minutes. The percentage of individuals with pupal wing pads and abnormal abdomens increases suddenly between the 15-20 and 25-30 minute exposures.

An analysis of the various types of abnormalities in the 76 abnormal

adults (graph 4) showed that the most frequent types are individuals with abnormal legs (69.7%) and elytra (57.8%). Of the leg abnormalities (95), absence of parts of the tibia or femur was most common (69.4%); 16.8% were of the tarsal type, and 13.6% lacked entire appendages or possessed only a coxa and trochanter. Only 17.1% possessed abnormal heads and 13% had abnormal antennae. Mouth-part abnormalities were rare (3.9%).

Stage III pupae were also subjected to the vapors for various lengths of time. The results are shown in graph 7. There is a steady decrease in normal and increase in abnormal beetles with increase in length of exposure. At this stage the percentage mortality does not go as high as that obtained from Stage I pupae (cf. graph 6). It will also be noted that the percentage of individuals with pupal wing pads and abnormal abdomens increases rapidly from exposures of 7-10 minutes and reaches 100% at 25-30 minute exposures (as compared to 70% from Stage I pupae).

The abnormalities were typical for this stage. Various parts of the appendages were missing (from those pupae which moulted). Elytra were diverging, swollen or unmelanized (rarely with parts missing—only one case). Parts of the appendages were unmelanized.

Apparently the length of exposure does not affect the type of injury but merely the percentage abnormality, normality, etc. From these experiments we may conclude that the age of the treated pupa determines, more or less, the type of injury obtained.

#### EFFECT OF DIRECT APPLICATION OF CHEMICALS

*The Application of Crystals of the Odoriferous Substance of Adult Tribolia.*<sup>3</sup>—To check on the previous results obtained by the direct application of the odoriferous substance to the leg region of last instar larvae (Roth and Howland, 1941), these crystals were again applied to 17 mature larvae. Six abnormal adults (35%) were obtained. One had a mesothoracic leg completely duplicated (see Roth and Howland, pl. I, fig. 5). The others had extra tarsal branches growing from the tibiae, while one interesting monstrosity apparently had made an attempt to form three separate legs from one imaginal disc (fig. 23).

*The Application of 10% HCl.*—In the experiments in which 10% HCl was applied to immature larvae 2.5-4.0 mm. long, four abnormal adults were obtained. One adult had an antennal club with fused segments; two others had a reduced and malformed mesothoracic and prothoracic leg, respectively, while the fourth had difficulty in moulting.

When 10% HCl was applied to immature larvae 4.5-5.0 mm. long, one of the five abnormal adults obtained had an abnormal tarsus; three others lacked parts of legs; the last had a reduced mesothoracic leg (about half normal size) and a reduced and malformed meta-thoracic leg.

The nine abnormal adults resulting from prepupae treated with 10% HCl lacked parts of legs or had abnormal tarsi. One failed to moult and another had difficulty in moulting because of a blackened region between the second and third abdominal sclerites which prevented the pupal skin from being sloughed off.

<sup>3</sup>See Footnote 2, p. 235.

*The Application of 19% HCl.*—When 19% HCl was applied to immature larvae 2.5–4.0 mm. long, two abnormal adults were obtained; one had the ninth and tenth segments of the right antenna partly fused, and the other had a small spur-like outgrowth on the tibia of the right metathoracic leg.

Immature larvae 4.5–5.0 mm. long treated with 19% HCl produced seven abnormal adults; one had malformed maxillary palps; the others lacked legs entirely, or lacked parts of legs, and had reduced and malformed appendages.

Treatment of last instar larvae with 19% HCl resulted in 24 abnormal adults that lacked parts of or entire legs, had abnormal tarsi (segments fused or missing), and had reduced and malformed legs (figs. 24–27, table I, and graph 2). In addition, two of these had an abnormal antenna (some of the segments fused), and two others had abnormal mouthparts (parts missing, and maxillary palps reduced).

Three larvae moulted into larvae with pupal characters (pupal wing pads and legs, but with larval abdomen and head). The antennae were neither pupal nor larval. These were almost identical with those reported and figured by Nagel (1934, figs. 2–4), obtained by subjecting mature larvae to various low temperatures. The present writer found three more of these metathetelous larvae in a culture of larvae reared away from adults. It is probable that the acid had little, if anything, to do with the production of these monsters. Similar abnormalities have been produced by subjecting mature larvae to high temperatures and to the vapors of carbon dioxide (Oosthuizen and Shepard, 1936).

The 34 prepupae treated with 19% HCl produced pupae lacking and with blackened structures. These produced adults with parts of the legs, mouthparts, and antennae missing. Leg abnormalities were most common.

Four of the eight abnormal adults resulting from pupae treated with 19% HCl could not get fully out of their pupal skins. Parts of the legs remained pupal. Two others had abnormal tarsi, and the others had parts of the legs missing (one of these also had the genae modified and a left maxillary palp missing).

*The Application of Concentrated HCl.*—When concentrated HCl was applied to last instar larvae, all of the 26 abnormal adults produced had abnormal legs, which were missing partly or entirely or were reduced and malformed (fig. 28; see also figs. 24–27, table I, and graph 2). One adult had an antenna of only three segments.

Affected prepupae gave the typical abnormalities. Large areas of the pupal legs were blackened and hardened. Those that metamorphosed lacked these structures.

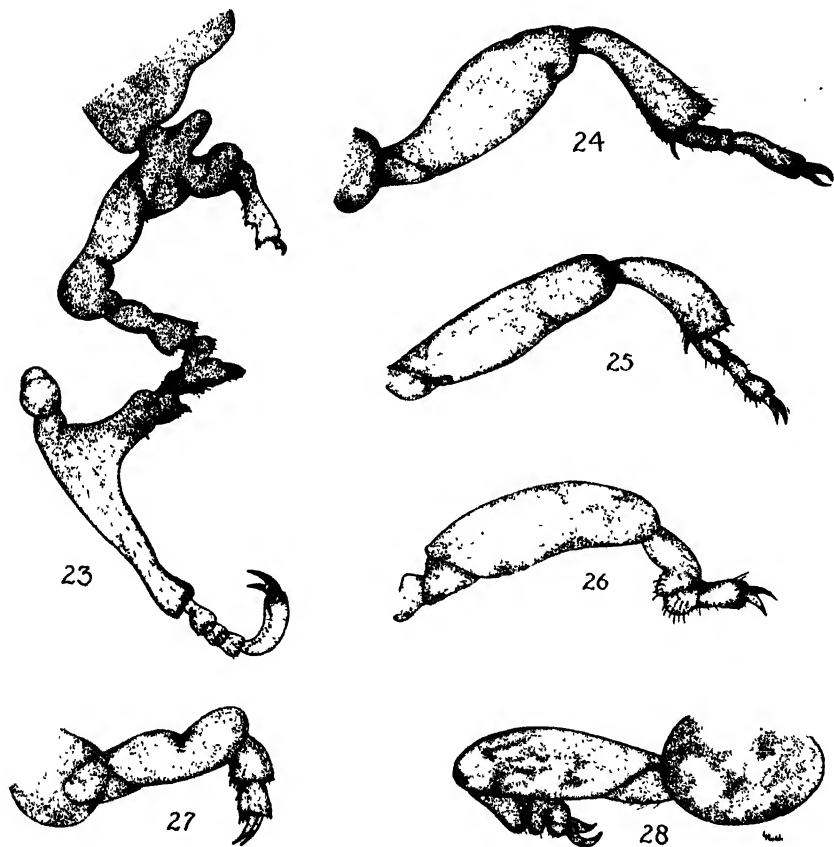
In the case of treated pupae of Stage I, the parts affected remained soft and white, and as usual were left behind in the moulted pupal skin.

*The Application of Glacial Acetic Acid.*—Glacial acetic acid was applied directly to last instar larvae, prepupae, and Stage I pupae. When applied to last instar larvae, the legs of the resulting adults were malformed, reduced, or had various parts missing. Tarsal segments were fused, or claws were absent. A few individuals had abnormal antennae and one interesting individual lacked part of the thorax.

Prepupae treated with glacial acetic acid produced pupae with

various appendages brownish black. In some, tarsal segments and other parts were missing. The resulting adults lacked parts of the legs.

Five of the abnormal adults resulting from Stage I pupae treated with glacial acetic acid could not emerge normally. The elytra were

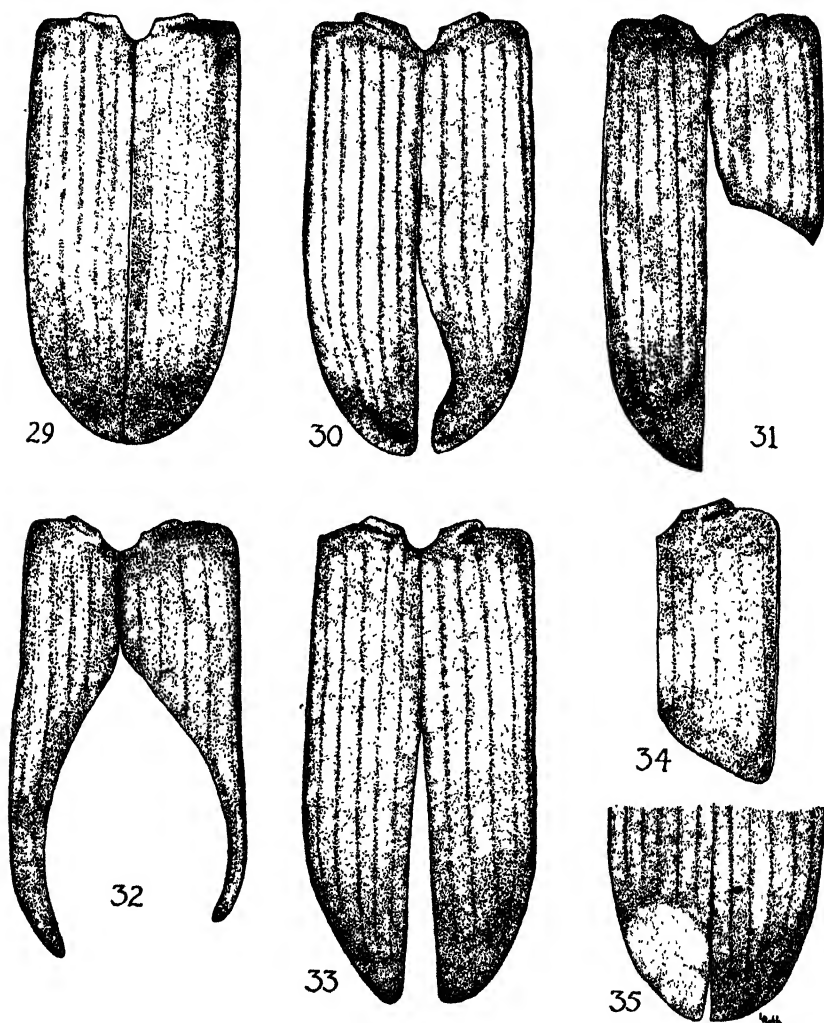


FIGURES 23-28

Tarsal abnormalities in *Tribolium confusum* (compare size and shape with figs. 14-16). Figure 23. Abnormal metathoracic leg obtained by applying crystals of the adult odoriferous secretion to the leg region of the last instar larva; an attempt has been made to form three legs. 24-27. Abnormal legs obtained by applying 19% HCl to the leg region of last instar larvae; all are reduced and malformed. 24. Abnormal prothoracic leg; there are only 4 tarsal segments and the first two are partly fused. 25. Abnormal mesothoracic leg; only two tarsal segments are present. 26. Abnormal metathoracic leg; only two tarsal segments are present. 27. Abnormal prothoracic leg; the tibia is absent and there are only two tarsal segments. 28. Abnormal mesothoracic leg obtained by applying concentrated HCl to the leg region of a last instar larva; the tibia is missing and only 3 tarsal segments remain, these being partly fused. Magnification, about 35X.

Abnormalities more or less similar to those in figs. 24-28 were also obtained from last instar larvae exposed to the vapors of glacial acetic acid.

abnormal and the abdomen remained soft and white. The others had abnormal tarsi and one also had a reduced maxillary palp and lacked the right elytron.



FIGURES 29-35

Elytral abnormalities in *Tribolium confusum*. Figure 29. Normal adult elytra. 30-34. Abnormal adult elytra obtained by subjecting Stage I pupae to the vapors of acetic acid. 30. Small portion of the right elytron missing. 31. About one-half of the right elytron missing. 32. Parts of both elytra missing. 33. Diverging elytra. 34. Part of the right and entire left elytron missing. 35. A balloon-like swelling at the base of the left elytron resulting from a Stage III pupa subjected to the vapors of acetic acid. The basal portions of the elytra are normal but not figured. Magnification, about 20 $\times$ .

## DISCUSSION

### EFFECT OF VAPORS

The experiments have shown that acetic acid vapors can induce the same abnormalities in *Tribolium confusum* as those obtained with the fumes of the odoriferous substance given off by the adults. A careful analysis has been made of the various types of abnormalities obtained from treating different stages of the beetle.

Although the vapors had been applied more or less diffusely, localized defects were produced. As Weiss (1939, p. 159) points out, this is undoubtedly due to the fact that the organism has the property of differential susceptibility, that is, there are some parts that are more sensitive than others and the same agent will affect some parts more strongly than others. "The striking parallelism between the gradient of susceptibility and that of metabolic rate has led to the contention that increased metabolic activity implies greater sensitivity. . . ." (p. 376).

In the present work, it has been shown that the type of abnormality obtained depends on the stage treated. The predominant types are listed in table II.

TABLE II  
PRINCIPAL DEFECTS PRODUCED IN ADULTS OF *Tribolium confusum*

STAGE TREATED	PREDOMINANT TYPE OF ADULT DEFECT (more than 25%)
Last Instar	<ol style="list-style-type: none"> <li>1. Antennal deformities; segments fused or missing.</li> <li>2. Mouthpart deformities; usually labial abnormalities (missing or reduced); maxillae may also be affected.</li> <li>3. Leg deformities; entire or parts of legs reduced and malformed.</li> </ol>
Prepupae (early)	<ol style="list-style-type: none"> <li>1. Antennal deformities; segments fused or missing.</li> <li>2. Mouthpart deformities; labium and maxillae missing.</li> <li>3. Leg deformities; parts of tibia or femur missing.</li> </ol>
Prepupae (late)	<ol style="list-style-type: none"> <li>1. Mouthpart deformities; maxillae usually abnormal (palps reduced or missing).</li> <li>2. Leg deformities; tarsal abnormalities; absence of parts of tibia or femur.</li> </ol>
Pupae (Stage I).	<ol style="list-style-type: none"> <li>1. Leg abnormalities; parts of femur and tibia generally missing.</li> <li>2. Elytral deformities; diverging; parts missing or unmelanized.</li> <li>3. Adults with pupal wing pads and abnormal abdomens. These may also possess pupal legs.</li> </ol>
Pupae (Stages II-IV).	<ol style="list-style-type: none"> <li>1. Adults with pupal wing pads and abnormal abdomens. Many may also possess pupal appendages.</li> <li>2. Those that develop and moult may lack parts of legs or have abnormally melanized appendages.</li> </ol>

Gassed last instar larvae produced adults with reduced and malformed appendages. In these larvae the cells of the imaginal discs were undoubtedly more or less equipotential in character, for although part of the disc had been injured or destroyed, it had still developed into an entire, though dwarfed, appendage. The appendage may also be

deformed, but in most cases the femur, tibia, and tarsus are all distinguishable.

Some adult legs from gassed last instar larvae were also partly or entirely missing. It might be argued that as the larvae become older the imaginal discs become more "determined" for the various parts of the legs so that any damage inflicted at this later stage would entail a corresponding defect in the appendage (lack of parts). However, although there may be such a critical period when the disc becomes "determined," this has not been shown in these experiments; it will be recalled that the direct application of 10% and 19% HCl to immature larvae also produced some adults with reduced and malformed and also missing appendages. This still leaves the possibility that the toxic substance may injure too much of an area to permit "regulation" (the formation of a whole, but reduced limb, from only a portion of the imaginal disc).

Bodenstein (1941) has shown that the legs of Lepidoptera in later caterpillar stages are still capable of "regulation," while in Diptera all major leg structures are already determined in corresponding stages.

In the previous work (Roth and Howland, 1941) with the vapors and crystals of the odoriferous substance, it was reported that affected last instar larvae gave only antennal and head deformities when treated with the vapors, while both leg and antennal abnormalities were obtained with the crystals. It was suggested that this was due to the greater toxicity and penetrating power of the melting crystals. In the present experiments, not only were antennal defects obtained but legs and mouthparts were also malformed. Acetic acid vapors are undoubtedly much more penetrating than those of the odoriferous substance. An exposure of only 2-4 minutes to the acid vapors gave a high percentage of abnormalities, while in the original work larvae were subjected to the odoriferous vapors for one hour and fifteen minutes.

It has been noted that there is a shift in the type and degree of abnormality with the developmental stage treated (graph 4). Abnormal adults obtained from treated prepupae and pupae usually lacked some structure. Again this is explained by Weiss (1939, pp. 482-483): "If a part drops out after a mosaic state has been attained the loss is permanent. . . . Differential susceptibility to the toxic agent likewise accounts for the suppression of localized parts. Which parts are suppressed depends on the developmental stage of the organism at the time when the agent strikes, since susceptibility varies with the degree of activity (metabolism?) and the centers of developmental activity shift from stage to stage."

It is interesting to note that in some cases the distribution of melanin seems to be related to the intensity of metabolism in the subjacent tissues (Wigglesworth, 1939, p. 333). Since, in *Tribolium*, the tarsal claws are among the first structures to become melanized (in the pupa), one might say that the cells of this region are probably more active than those in other parts of the leg, throughout its formative period; many treated prepupae produced adults lacking tarsal claws or possessing other tarsal abnormalities. It should be remembered, however, that the tips of the mandibles become pigmented at about the same time as the tarsal claws, and although mouthpart deformities were obtained from treated prepupae, very few affected the mandibles specifically.

Early prepupae may moult into pupae lacking parts of the appendages. Apparently the legs, mouthparts, and antennae of this stage are still in the formative stage and have not been everted; when parts are destroyed at this time, they are missing from the pupae and consequently from the adults. Later prepupae produce pupae with necrotic appendages and these were affected after the appendages had already been evaginated. Horsfall (1934) also found that prepupae of *Tribolium* give rise to more abnormalities than pupae when given the same dosage of ethylene oxide vapors.

The prepupal stage (particularly the early prepupa) is the most critical in the development of *Tribolium*, for it is at this period that the most drastic abnormalities can be induced. However, prepupae can withstand longer exposures than either larvae or pupae. A comparison of mortality curves (graphs 1, 3, 6, 7) shows that all larvae are killed by a 15 minute exposure, whereas prepupal mortality did not exceed 10%, and the highest mortality for Stage I and III pupae (for exposures between 2-15 minutes) was 6.6%. In one experiment Stage IV pupae gave a 54% mortality after a 15 minute exposure (see graph 5). Between exposures of 15 and 30 minutes, prepupae and Stage III pupae reached a mortality peak of 20% while the mortality of Stage I pupae rose to 66.6%.

Wigglesworth states (1939, p. 340) that metabolism at a given temperature is generally much higher in the larva than in the pupa, this being mainly the result of differences in muscular activity. The oxygen intake is also greater in active insects. This may explain the death of all larvae after 15 minutes whereas the other stages can withstand longer exposures. Larvae, being more active, take in more oxygen, and consequently more vapors of acetic acid. The high mortality of Stage I pupae (particularly early Stage I) is undoubtedly due to the soft and permeable condition of the still unsclerotized cuticle, through which the vapors can readily penetrate. Moore (1916) has shown that gases can penetrate through other parts of the body than the spiracles (through thin layers of chitin). However, Stage IV pupae also gave a high mortality and by this time the cuticle has become more hardened.

Affected pupae often produced adults with abnormally melanized regions and many beetles possessed an entirely unpigmented or only partly pigmented abdomen. It is well known that the deposition of melanins requires the interaction of tyrosinase, chromogen, and oxygen. "In general it seems to be the localization of chromogen which determines the distribution of the pigment patterns; chromogens are absent from white areas of cuticle whereas tyrosinase is present everywhere" (Wigglesworth, 1939). Thus it is highly possible that in these abnormally pigmented individuals the formation of chromogen has been interfered with. Oosthuizen (1935) also found that many adults developing from pupae exposed for short periods to 44° C. had deformed wings or a pupa-like abdomen.

#### EFFECT OF DIRECT APPLICATION OF CHEMICALS

The direct application of concentrated acetic acid and various concentrations of hydrochloric acid to the different stages of *Tribolium* produced essentially the same results as those obtained by the use of acetic acid vapors. In all larvae treated there was only one case of an



adult with an accessory outgrowth (an immature larva treated with 19% HCl produced an adult with a small spur-like outgrowth from the tibia).

Thus the leg deformities obtained with various chemicals were different from those obtained with the crystals of the odoriferous substance. In no case were duplications or tarsal-like outgrowths obtained with the former. It was originally suggested that regeneration of injured discs resulted in these duplications. However, if this is the case, it is unusual that similar deformities were not obtained after injury with HCl or acetic acid (an injury which was not too drastic to prevent the formation of a reduced appendage). Actually the duplication may have resulted from a splitting of the disc by the toxic agent. As Weiss points out (1939, p. 482), "Accidental splitting of the company of cells in the germ (in the preliminary phase, prior to final determination), may cause twinning and when the same accident happens to an organ rudiment in its equipotential state, reduplications of various degrees may be produced."

However, this still does not explain the fact that this type of injury was not obtained with the use of other chemicals. From the various outgrowths also obtained with the odoriferous crystals, there seems to be a tendency toward a stimulation of growth (see fig. 23). So we finally return to Chapman's (1926) original suggestion that the odoriferous substance of *Tribolium* may have a tendency to stimulate when given in a minimum dose, while in a maximum dose it may be lethal.

### SUMMARY

1. Various stages of *Tribolium* have been subjected to the vapors of acetic acid. The results were more or less similar to those obtained with the vapors of the odoriferous substance given off by the adults. In the present work a detailed analysis has been made of the types of abnormalities produced. The type of deformity induced is determined by the developmental stage of the animal at the time of treatment; and this type changes with a change in the developmental stage.

2. Glacial acetic acid and various concentrations of hydrochloric acid were also applied directly to different stages of *Tribolium*. The results were essentially the same as those obtained by the use of acetic acid vapors. In only one case was an accessory outgrowth induced and never were any duplications or triplications obtained.

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**NOTES ON ECUADORIAN BUTTERFLIES. IV.**  
**THE GENUS *PENROSADA*, NEW**  
**(Lepidoptera, Satyridae)**

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The members of the genus *Penrosada* have heretofore been placed in the genus *Lymanopoda*, but they differ from the species which really belong to *Lymanopoda* both superficially and structurally. Superficially, they are smaller, and have a normal wing shape; the most striking structural differences are to be found in the male genitalia. There is marked uniformity in the trend of variation within each species. On the east slope of the Andes these insects seem to be restricted to the temperate forests, and they abound in the more moist regions near the tree line; on the western slope they descend into the subtropics.

I wish to thank the following men and institutions for allowing me the privilege of examining material in their charge: Mr. William P. Comstock, of the American Museum of Natural History; Dr. J. W. Cadbury 3rd, of the Academy of Natural Science, Philadelphia; Dr. William D. Field, of the U. S. National Museum; Dr. A. A. Avinoff, of the Carnegie Museum, Pittsburgh; and Dr. W. T. M. Forbes, of Cornell University. Dr. Field kindly made the dissection of the type of *P. keithi* and sent me drawings from which I drew the figure here presented (fig. WDF).

***Penrosada*, new genus**

Eyes usually glabrous to very weakly haired; antennae composed of 38 segments, of which 10 or 11 form the club (fig. 1669F); palpi similar to those of *Lymanopoda*, but much more densely haired (fig. 1669E). Prothoracic legs similar to those of *Lymanopoda* (fig. 1669C).

Fore wing with costal margin generally less than an inch in length, the costal and outer margins gently curved; apex of wing angular, sometimes sharply so but never produced or falcate. Hind wing with outer margin smoothly rounded or slightly undulant, never angular; anal margin usually slightly incised near anal angle. Venation of fore wing similar to that of *Lymanopoda*, particularly bases of veins and branching of radius, but differing in lacking medial stalk and crossvein connecting radius with  $M_1$ ;  $M_1$  originating on radius (fig. 1669A). Venation of hind wing differing from that of *Lymanopoda* in that the crossvein between  $M_1$  and  $M_2$  is shorter and more gently curved, and  $M_1$  lies much closer to  $Cu_1$  than to  $M_2$  (fig. 1669B).

Variation in male genitalia from species to species less striking than in *Lymanopoda*. Uncus simple, about as long as or longer than "shoulder" of vinculum; two prominent subuncal prongs; vinculum slender; saccus short; valves small, with a well developed sacculus; distal process present, but no dorsal process in any of the species

examined; tip of distal process armed with a few large teeth; aedeagus short, curved, heavy, often "humped" toward the base, not toothed.

*Type*.—*Lymanopoda leaena* Hewitson.

I have named this genus in honor of Mr. Spencer Penrose, founder of the Cheyenne Mountain Zoological Society and Museum, who generously made available the funds to include a botanist in our field party in Ecuador.

#### KEY TO THE SPECIES OF PENROSADA

1. Neither light spots nor a light band across under side of hind wing. . . . . 2  
Either light spots or a light band across under side of hind wing . . . . . 5
2. A discrete partial row of pupillated spots on upper side of hind wing. . . . . 3  
These spots lacking. . . . . 4
3. A definite but obscure reddish brown transverse band on under side of hind wing. . . . . *apiculata* (Felder)  
This band lacking. . . . . *cillutinarca* Weymer
4. A row of white spots on under side of hind wing, at least some of which are surrounded with black. . . . . *cillutinarca* Weymer  
These spots lacking. . . . . *lanassa f. neglecta*
5. A transverse row of light spots on under side of hind wing. . . . . 6  
A solid light band across under side of hind wing. . . . . 7
6. At least seven spots on under side of wing, the outer margin of the row straight. . . . . *lanassa f. discontinua*  
Four or five spots on under side of wing, the outer margins of these rounded, . . . . . *apiculata f. interrupta*
7. A bright burnt orange band across upper side of hind wing, or a large diffuse area of rusty brown at anal angle. . . . . 8  
Upper side of hind wing more or less concolorous. . . . . 9
8. A bright burnt orange band across upper side of hind wing. . . . . *lisa* Weymer  
A large area of rusty brown on upper side of hind wing, at anal angle, . . . . . *lisa f. reducta*
9. Light band across under side of hind wing uniform in width. . . . . *leaena* (Hewitson)  
This band irregular in width. . . . . 10
10. A strongly developed submarginal row of ocelli on under side of hind wing. . . . . 11  
At most only discrete ocelli on under side of hind wing. . . . . 12
11. An ocellus on under side of fore wing. . . . . *satura* Weymer  
No ocelli on under side of fore wing. . . . . *keithi* Dyar
12. A partial row of discrete ocelli on upper side of hind wing, . . . . . *apiculata f. curvilinea* (Weymer)  
These ocelli absent. . . . . *lanassa* (Felder)

#### *Penrosada leaena* (Hewitson)

Figures 1613 and 1669

1862. Hewitson, Jour. Entomology, 1: 156, pl. 9, fig. 1.

*Type Locality*.—Columbia (?).

*Range*.—Columbia, Ecuador, and Bolivia.

*Material Examined*.—Tungurahua, Ecuador: 7♂ and 2♀ 22.XI.38, 2800 m. (F. M. B.), and 2♂ 9.I.39 (W. C.-M.), Runtún, near Baños; 5♂ 1.XII.38, 2300 m. (W. C.-M.), Pundoa, near Baños; 1♂ 15.X.38, 2200 m. (W. C.-M.), San Pablo, near Baños; 1♂ X.38, 2200 m. (W. C.-M.), 1♂ 14.V.39, 2000 m. (W. C.-M.), 1♂ 5.I.39, 1900 m. (W. C.-M.), 1♂ 8.XI.38 (W. C.-M.), 1♂ 18.X.38, 1700 m. (W. C.-M.), and 1♂ II.39 (J. E. S.), Baños; 4♂ 18.X.38, 2000 m. (W. C.-M.), Rio Blanco, near Baños; 1♂ X.39, 1400 m., (J. E. S.), Chinchin Grande; 1♂ 1.X.38, 1200 m. (F. M. B.), Hda. San Francisco.

This species is quite common in the temperate and upper subtropical forests. Whympers collected two specimens at Machachi, 10,000 feet elevation, in the semi-arid interandean plateau. Stübel took it on the road from Quito to Manabí, between 2500 and 2800 meters. Dognin reported it among Gaujon's catches in the "vicinity of Loja." At least one of these Dognin specimens is a form of *apiculata*. Coxey collected two specimens at Hda. Licay, above Huigra, 7000 feet, 29.VII.32, on the western slope. Bolivia is included in the range of this species on the basis of a specimen from Cochabamba collected by José Steinbach and in the Carnegie Museum (Acc. 6873). Kirby gives Nauta as a locality for the species in his catalogue (p. 102); this is obviously incorrect.

### **Penrosada apiculata** (Felder)

Figure 1622

1867. Felder, Reise Novara, Lepidoptera, 3: 474.

Synonym: *harknessi* Dyar, Proc. U. S. N. M., 45: 634; 1913.

*Type Locality*.—Bogotá, Colombia (Lindig).

*Range*.—Colombia to Peru.

*Material Examined*.—Azuay, Ecuador: 1♂ 15.II.39, 2700 m. (F. M. B.), Seville de Oro; 1♂ 16.II.39, 2800 m. (F. M. B.), trail between Pan and Paute.

These two specimens were taken in the semi-arid grasslands—bush country of the temperate region. They differ in minor respects from the descriptions of the species and from Weymer's figure in Seitz'. The rusty markings on the under side of the hind wings are quite obscure, and the lilac-gray margins of the same surfaces are broader. On the upper surface of the hind wings there is a pair of tiny white-pupilled ocelli. Until these specimens are carefully compared with a reasonably long series of Colombian specimens I feel that it is better to leave them uncumbered by a subspecific name.

The male genitalia of *apiculata* (fig. 1622) are much like those of *leacna* (fig. 1613). They differ slightly in the shape of the distal process of the valve and of the aedeagus. However, I would hesitate before separating the two species solely on the basis of genitalia.

### **Penrosada apiculata** form **interrupta** new form

Figure 1618

*Holotype*.—♂ 15.II.39, 2500 m., Seville de Oro, Azuay, Ecuador (No. B1618). *Paratypes*: 1♂ 1.VIII.32 and 1♂ 25.VII.32, 4000 ft. (W. J. Coxey), Huigra, Ecuador (Acad. Nat. Sci. Phila.).

The holotype of this interesting form was collected in a dry grassy field on the steep slopes lying east of the town. It differs from typical *apiculata* in having a row of four creamy white spots across the disc on the obscure rusty red band on the under side of the hind wings. The costal spot of the four is minute, and the one on the anal margin is double. These spots are subtriangular in shape, with their rounded apices marginad, and all except the anal spot are higher than wide. These spots are widely separated. The paratypes differ slightly in the size of the spots; on the Aug. 1 specimen they are smaller, and on the July 25 specimen they are larger.

**Penrosada apiculata form curvilinea** (Weymer)1912. Weymer, Seitz' *Macrolepidoptera*, 5: 248.*Type Locality*.—Boqueron de Chipaque, Cord. Oriental, Colombia, 3200 m. (Fassl).*Range*.—Colombia and Ecuador.*Material*.—Four specimens were taken by W. J. Coxey at Huigra, Ecuador, 4000 ft., 25.VII-1.VIII.32, on the western slope; these are in the collections of the Philadelphia Academy of Natural Science. There is a single specimen of this form in the U. S. National Museum from the Dognin collection; the data given on the pin label read "Environs of Loja."

This form might easily be confused with either *leaena* or *lanassa*. From the former it may be distinguished by the irregularity of the light band on the under side of the hind wing, the regularity and sharp definition of the zigzag lines on the under side paralleling the margin, especially on the fore wing. From *lanassa* it may be distinguished by the distinct ocelli on the upper side of the hind wing, the much less uniform light band on the under side of the hind wing, and the much more acute angles in the zigzag line on the veins. I suspect that Dognin confused his specimen with *leaena* in his published list.

The male genitalia (B1682 in U. S. N. M.) are like those of *apiculata*.

The insect described as *saturata* by Weymer in Seitz' (5:249) may be a form of this species or the next. The position of the light band on the under side of the hind wings indicates that it is not *leaena*. He reports it from Colombia (Quindiu Pass) and Peru (Cuzco). Both of these stations are on the west slope of the Andes. I have not seen it from Ecuador, but the region where it should fly in Ecuador has barely been visited by entomologists. *L. keithi* Dyar seems to me to be a synonym of *saturata*. If the Colombia and Peru forms prove to be distinct, Dyar's name should be applied to the Peru form and Weymer's name to the Colombia form. The genitalia of the type of *keithi* is shown in figure WDF.

**Penrosada lanassa** (Felder)

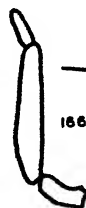
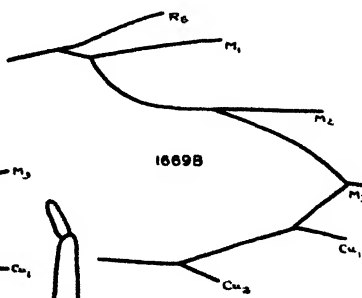
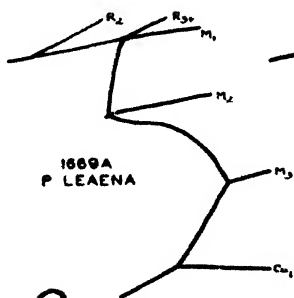
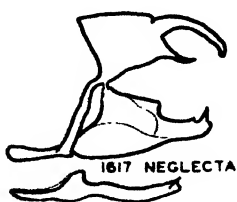
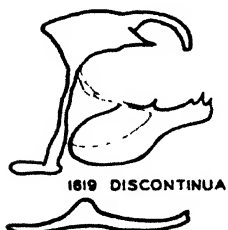
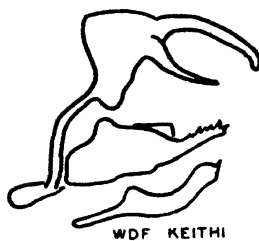
Figure 1616

1867. Felder, *Reise Novara, Lepidoptera*, 3: 474*Type Locality*.—Bogota, Colombia (Lindig).*Range*.—Colombia and Ecuador.

*Material Examined*.—1♂ S.IV.39, 3200 m. (F. M. B.), Minza Chica, Tungurahua; 1♂ XI.39 (W. C.-M.), Pappallacta to Archidona, Napo-Pastaza; 1♂ XI.39 (W. C.-M.), Quito to Rio Toachi, Pichincha. I can vouch for the data on the Minza Chica specimen because I caught it,

## EXPLANATION OF PLATE

Genitalia and other structures of *Penrosada*. Figure 1613, *leaena* (Baños, 18 X.38, 1700 m.); 1616, *lanassa* (Minza Chica, 8.IV.39, 3200 m.); 1617, *lanassa* form *discontinua*, holotype; 1618, *apiculata* form *interrupta*, holotype; 1619, *lanassa* form *neglecta*, holotype; 1622, *apiculata* (Pan to Paute, 16.II.39, 2800 m.); 1637, *lisa* (Huancayo, Peru, ex Johnson, 3500 m., lot 39, A. M. N. H.); 1643, *cillulinarca* (road between Cocopuncu and Pararani, Bolivia, 5,200-10,000 ft., 29.III.26, ex Tate, A. M. N. H.); 1669, *leaena* (Runtún, 22.XI.38, 2800 m.); a—venation at the end of the cell of the fore wing, b—venation at the end of the cell of the hind wing, c—prothoracic leg, d—tegula, e—palpus, f—club of the antenna; WDF, *keithi*, holotype (after mss. drawing by W. D. Field).



but the two obtained from Macintyre were bought in Quito from bird collectors (the Olalla's?), and each bore obviously incorrect locality data far down in the humid tropical jungle. The localities given above are the trails to the localities given on the papers enclosing the specimens.

Coxey collected four specimens at Huigra, Ecuador, 4000 ft., 20.VII-1.VIII.32, and four at Hda. Licay, above Huigra, 7000 ft., 17-29.VII.32, on the western slope. These are in the collections of the Philadelphia Academy of Natural Science.

Weymer's designation of this species as a "race" of *laena* Hew. is incorrect on both pattern and genitalia of the males.

On the basis of pattern and genitalia the following two new forms belong to this species.

***Penrosada lanassa* form *discontinua* new form**

Figure 1617

*Holotype*.—♂ (No. B1617) 8.IV.39, 3200 m. (F. M. B.), Minza Chica, Tungurahua, Ecuador.

In this form the yellowish band on the under side of the hind wings is crossed by dark brown lines on the veins, breaking the band into a series of quadrate spots that are clearly separate. The male genitalia differ slightly from those of typical *lanassa* in the line of the upper margin of the valves. In this respect the genitalia resemble those of *keithi* (fig. WDF).

***Penrosada lanassa* form *neglecta* new form**

Figure 1619

*Holotype*.—♂ (No. B1619) 8.IV.39, 3200 m. (F. M. B.), Minza Chica, Tungurahua, Ecuador.

On this form there is no trace of the yellowish band across the disc of the under side of the hind wings. The discrete white spots on the upper side of the wings are similar to those in *lanassa*. The male genitalia (fig. 1619) are similar to those of *lanassa* (fig. 1616). The form *neglecta* differs from *cillutinarca* Weymer (fig. 1643), with which it might be easily confused, both in genitalia and pattern. In *cillutinarca* the uncus is proportionally longer and the aedeagus lacks the "hump" found in *lanassa* and its forms. In pattern the differences are less visible but *neglecta* lacks the submarginal ocelli that are always present on the under side of the hind wings of *cillutinarca*.

The only specimens of *cillutinarca* that I have seen are from Bolivia, taken between Copunco and Pararani in 1926 by Mr. G. H. H. Tate of the American Museum of Natural History.

***Penrosada lisa* form *reducta* new form**

*Holotype*.—♂ (No. B1681) VIII.1911, Rio Pampaconas, Peru (Yale Peruvian Expedition, U. S. N. M.). *Paratype*: ♂ VIII.1911 (Yale Peruvian Expedition, U. S. N. M.).

This form differs from the typical form in having the orange wedge across the upper side of the hind wings reduced to a large rusty-brown area on the anal angle and margin.

The specimens of *lisa* and its probable form *reducta* that I have seen all came from central Peru. These two forms are in the American Museum of Natural History and the U. S. National Museum respectively.

**A REVISION OF THE NORTH AMERICAN SPECIES  
BELONGING TO THE GENUS HYDROPHORIA  
ROBINEAU-DESVOIDY**

**(Diptera: Muscidae)**

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Flies of the anthomyid genus *Hydrophoria* Robineau-Desvoidy occur commonly in the vicinity of woodland streams, lakes and moist terrain. Certain species, such as *H. nigerrima* Malloch, are known only through capture on higher mountain ranges, whilst a few are evidently restricted in habitat to boreal regions. The larvae, so far as is known, are aquatic. Twenty-seven species are herein recorded from North America.

The genus *Hydrophoria* is not readily defined for diagnostic purposes despite the fact that the species may be fairly readily grouped owing to their affinity. Two segregates lie within the genus, as exemplified in *Anthomyia conica* Wiedemann and *Anthomyia divisa* Meigen respectively. Schnabl and Dziedziicki (1911)<sup>1</sup> have applied the names *Hydrophoria* and *Acroptena* to denote these groups. The characters that I have found of value for distinguishing the genus *Hydrophoria* from allied segregates are as follows: The species lack any bristle or setae on the thoracic pteropleura as in *Emmesomyia* and *Taeniomyia sensu* Malloch, the dorsal bristle of mesopleural series is proportionately stronger than in *Neohylemyia* and most *Hylemyia*, the hind tibiae possess more bristles on the anterodorsal and posterodorsal surfaces than the normal two or three pairs present in *Pegomyia*, except in *divisa* and *proxima* where there are normally two postero-dorsal bristles. Most of the North American species are blackish including the appendages of head and thorax. Notable exceptions in this regard are *conica*, *ruralis*, *galeata*, *divisa*, *katmaiensis* (♀), *brunneifrons* (♀), where the tibiae are or may be more or less yellow. The thorax in many species is marked by three dark broad vittae, and the terminal sclerites of ovipositor are armed with short recurrent spinules except in the cases of *laticornis* and species comprising the *frontata* group. The mid tibia has a medial antero-ventral bristle except in *divisa*, *conica*, *ruralis*, and *galeata*. The following species possess hairs on the upper border of the hypopleura: *frontata*, *verticina*, *nigerrima*, *polita*, *packardi*, *brunneifrons*, *katmaiensis*, *divisa*, and also, though not invariably, in *proxima* and *laticornis*. The males of the following species possess a tuft-like growth of bristles on the lateral borders of the fourth abdominal tergum: *alaskensis*, *borealis*, *fasciculata*, *lucidiventris*, *wierzejskii*, *ambigua* Stein not Fallén.

I wish to express my acknowledgment for assistance from the following institutions in the loan of material: United States National

<sup>1</sup>Reference to literature cited in the synonymies is signified by date of publication.



Museum [U. S. N. M.], Division of Entomology of the Canadian Department of Agriculture [C. N. C.], University of Alberta, American Museum of Natural History [A. M. N. H.], New England Museum of Natural History [N. E. M. N. H.], Cornell University [C. U.], Oregon State College, Michigan State College, Utah Agricultural College, Montana Agricultural Experiment Station, Brigham Young University. It has also been my privilege to examine material in the private collections of Dr. D. G. Hall, Dr. A. L. Melander, Dr. F. M. Snyder, and Mr. R. E. Rieder, opportunities for which I am deeply grateful.

### CRITICAL NOTES ON THE LITERATURE PERTAINING TO NORTH AMERICAN SPECIES

The earliest reference to species of the genus occurring in North America may be found in Walker's (1849) list of dipterous insects in the British Museum of Natural History, in which he described the form *Anthomyia teale* from the Hudson Bay region. Stein (1901, 1907) considered the species as apparently the same as the European form *Anthomyza brunneifrons* Zetterstedt. In 1857 Schiödt recorded the presence of *Anthomyza frontata* Zetterstedt from Greenland, a species which was later reported from the same region by Boheman (1865) under the name *Scatomyza obscura*.

In 1878 Meade<sup>2</sup> published notes on a collection of flies belonging to the Museum of Comparative Anatomy at Cambridge which had been sent to him by Baron Osten Sacken for purposes of identification in which the former mentioned the recognition of three species belonging to *Hydrophoria*, one being similar to *Anthomyia ambigua* Fallén. In the same year Osten Sacken,<sup>3</sup> furnished with this information, included the genus in his catalogue of North American Diptera, mentioning no species. Hagen<sup>4</sup> on the return of the collection to the Museum amplified Meade's comments but gave no additional information concerning the identity of the species.

Bigot<sup>5</sup> in 1885 described *Hydrophoria nigricauda* from the Rocky Mountains and *H. pictipes* and *H. calopus* from Mexico. The former species is in my opinion more properly placed in *Neohylemyia* Malloch, and the latter two, according to Stein (1919) and Séguy (1937), belong to *Taeniomyia* Stein and *Bilhoracochaeta* Stein respectively. In 1896 Van der Wulp<sup>6</sup> employed the genus for the reception of four new Mexican species, all of which with the possible exception of *plumosa* may be regarded as belonging to *Emmesomyia* or *Taeniomyia*, as recently indicated by Van Emden<sup>7</sup>, rather than to *Hydrophoria* of authors.

<sup>2</sup>Meade, R. H. Notes on the Anthomyidae of North America. Ent. Month. Mag., (1877-1878), 14: 250-252, 1878.

<sup>3</sup>Osten Sacken, C. R. Catalogue of the described Diptera of North America. Misc. Coll. Smithsn. Inst., III, No. 270, p. 165, 1878.

<sup>4</sup>Hagen, H. A. List of N. American Anthomyidae, examined by R. H. Meade, Esq., Bradford, England. Can. Ent., 13 (3): 46, 1881.

<sup>5</sup>Bigot, J. M. F. Diptères nouveaux ou peu connus. 25<sup>e</sup> Part. XXXIII. Anthomyzides nouvelles. Ann. Soc. Ent. France, (1884), 6<sup>e</sup> ser., No. 4, pp. 274-277, 1885.

<sup>6</sup>Van der Wulp, F. M. Insecta, Diptera. Biol. Centr. Amer., 2: 332-334, 1906.

<sup>7</sup>Van Emden, F. I. Keys to the Muscidae of the Ethiopian Region: Scatophaginae, Anthomyiinae, Lisiinae, Fanniinae. Bull. Ent. Res., 32 (3): 258, 1941.

Lundbeck (1898) in reporting on the fauna of Greenland provided fresh data concerning the distribution of *brunneifrons* and *frontata*, both of which are referred to the genus *Hylemyia*. He added *divisa* Meigen to the records from this region as a *Spilogaster*. Twenty years later, in a joint study of the land arthropods with Henriksen (1917), these species were transferred to *Hydrophoria* and *Acroptena* respectively. More recently material collected from the circumpolar regions has been studied by Malloch (1918, 1934), Collin (1923, 1924, 1931), Longstaff (1936), Carpenter and Holm (1939), in which two additional forms are recognized, namely the native species *arctica* and the European form *Anthomyza verticina* Zetterstedt.

In 1898 Stein reported the occurrence of *divisa* and *ambigua* from the United States, the latter species being represented by material from Massachusetts and Illinois. In my opinion Stein was mistaken here in his recognition of *ambigua*, and this error has given rise to the commonly accepted belief that Fallén's species occurs widely in the United States east of the Rocky Mountains. The distribution of the true *ambigua* so far as available records would indicate is confined to the western States and Alaska (Coquillett, 1900). Stein's *ambigua* in the above instance is an unnamed species. The same author (1904), from a study of exotic material in the National Museums at Berlin and Budapest included in *Hydrophoria* two North American forms which he had earlier described as *Spilogaster hilariformis* and *S. socialis*. These species belong respectively to Malloch's segregates *Dendrophaonia* and *Emmesomyia*. Only two North American species are included by Stein (1919) under *Hydrophoria* in his extensive annotated list of exotic anthomyian flies, namely *H. nigricauda* Bigot and *Anthomyia teate* Walker. The Mexican species *Hylemia tenuirostris* Van der Wulp is cited by Stein as a synonym of *nigricauda*, in which case it seems probable that Bigot's species is nearer *Neohylemyia* Malloch than to *Hydrophoria*. Stein's (1920) second large contribution to the North American fauna of Anthomyiidae contains the records of three species under *Acroptena* and one in *Hydrophoria*, of which the European forms *A. ignobilis* (Zett.) and *H. ruralis* (Meigen) are new additions.

Aldrich (1905) in cataloguing the two-winged flies of North America cited ten nominal species under *Hydrophoria*, including therein the Mexican records of Bigot and Van der Wulp. Of this number only *ambigua*, *divisa* and *teate* may be regarded as belonging to the genus as here delimited.

Malloch (1918, 1919, 1920, 1924, 1934) in a large number of contributions to the nearctic fauna has recorded the presence of nearly twenty species, of which the great majority were regarded as native forms. Keys were published to males of eighteen species and to females of thirteen. Malloch finally recognized the *Acroptena* group as apart from *Hydrophoria*, placing in the former those species possessing fine hairs on the upper anterior margin of the hypopleura, and retaining the latter name for those lacking this character. A more detailed treatment of Malloch's species may be found in the discussion of taxonomy and relationships forming the latter part of this revision.

The fauna of the different states and provinces has been compiled by Cole and Lovett (1921) for Oregon, Huckett (1924) and Leonard (1928)

for New York, Johnson (1925, 1927) for New England, Hallock and Parker (1926) for New Jersey, Brimley (1928) for North Carolina, and Strickland (1938) for Alberta. Of the New York records it may be pertinent to mention that later studies have shown that *orientalis* is the same species as *Pegomyia palposa* (Stein), and that *flavohallerata* has been mistakenly included. Of the Alberta fauna, the striking species *wierzejskii* (Mik) had been earlier recorded from Washington by Malloch (1920) as *H. elongata*. The species listed in the provincial records as *bispinosa* and *oculta* are evidently names that properly belong to the genus *Hydrotalea*.

Séguy (1937) referred to the genus as *Hydrophoria* in "Genera Insectorum." He proceeded to distinguish the two segregates *Hydrophoria* and *Acroptena* by a series of arbitrary characters, which he concluded could scarcely be applied satisfactorily. Hence he decided to include the two segregates under one generic name. There are sixty-seven nominal species listed in the genus, of which twenty-seven are mentioned as occurring in the nearctic region, including, in my opinion, the nongeneric forms *nigricauda* and *orientalis*.

In the present study twenty-seven species are recognized as occurring in North America, of which two are described as new. Of this number twelve were first recorded from Europe, one from Siberia, and fourteen from North America.

### Genus *Hydrophoria* Robineau-Desvoidy

*Hydrophoria* Robineau-Desvoidy, Essai Myod., p. 507, 1830; Macquart, Hist. Nat. Ins., 2: 297-302, 1835; Rondani, Dipt. Ital., Prodr., 6: 12, 1877; Meade, Ent. Month. Mag., (1881-1882), 18: 101-104, 1881; Strobl, Verh. zool.-bot. Ges. Wien, 43: 242-245, 1893; Meade, Descr. List Brit. Anth., 1: 29-32, 1897; Aldrich, Misc. Coll. Smithsn. Inst., 46 (1444): 551, 1905; Stein, Kat. Paläarkt. Dipt., 3: 684-687, 1907; Schnabl and Dziedzicki, Abh. K. Leop.-Carol. Deutsch. Akad. Naturforsch., 95 (2): 102, 1911; Stein, Arch. f. Naturgesch., (1913), 79 A (8): 31, 1914; Stein, Arch. f. Naturgesch., (1915), 81 A (10): 135-138, 221, 1916; Henriksen and Lundbeck, Gronlands Landarthropoder, p. 639, 1917; Stein, Arch. f. Naturgesch. (1917), 83 A (1): 149, 1919; Malloch, Can. Ent., 52: 253-257, 1920; Séguy, Faune de France, 6: 140-142, 1923; Hockett, Mem. 77, N. Y. (Cornell) Agr. Exp. Sta., (1923), pp. 14-16, 1924; Karl, Tierwelt Deutschlands, 13 (3): 117-119, 1928; Tiensuu, Acta Soc. Faun. Flor. Fenn., 58 (4): 31, 1935; Séguy, Gen. Insect., Fasc. 205, pp. 130-135, 1937.

*Zaphne* Robineau-Desvoidy, Essai Myod., p. 527, 1830; Coquillett, Proc. U. S. Nat. Mus., 37: 621, 1910.

*Acroptena* Pokorný, Wien. Ent. Zeitg., 12 (2): 60-63, 1893; Stein, Kat. Paläarkt. Dipt., 3: 683, 1907; Schnabl and Dziedzicki, Abh. K. Leop.-Carol. Deutsch. Akad. Naturforsch., 95 (2): 102, 1911; Stein, Arch. f. Naturgesch., (1913), 79 A (8): 31, 1914; Stein, Arch. f. Naturgesch., (1915), 81 A (10): 132-136, 221, 1916; Henriksen and Lundbeck, Gronlands Landarthropoder, p. 638, 1917; Ringdahl, Ent. Tidskr., 39 (2): 186-188, 1918; Stein, Arch. f. Naturgesch., (1917), 83 A (1): 149, 1919; Séguy, Faune de France, 6: 143-147, 1923; Karl, Tierwelt Deutschlands, 13 (3): 119-121, 1928; Malloch, Mem. Carnegie Museum, 12 (Pt. II, Sect. 4): 25, 1934; Tiensuu, Acta Soc. Faun. Flor. Fenn., 58 (4): 31-32, 1935.

*Anthomyia* (*Hydrophoria*) Pandellé, Rev. ent. France, 19: 218-222, 1900.

*Genotype*.—*Anthomyia conica* Wiedemann (= *Hydrophoria tibialis* and *H. saggittariae* Rob.-Desv.) by designation of Rondani (1877).

The genus *Hydrophoria* Robineau-Desvoidy (1830) was erected for the reception of nine nominal species, none of which have since been recognized with any degree of confidence by subsequent authors. In 1840 Westwood<sup>8</sup> designated *Musca nigrita* Fallén as the genotype of *Hydrophoria*. Fallén's species was regarded by Macquart (1835) as identical with *Hydrophoria littoralis* Robineau-Desvoidy, the last of the species originally placed in the genus. In 1910 Coquillett designated *Musca vespertina* Fallén (not Malloch)<sup>9</sup> as the genotype of *Hydrophoria*, a name used in preference to *nigrita* for reasons of priority in the belief that the two species were the same. This interpretation of the species was later noted by both Stein (1907) and Séguy (1937). However in 1838 Zetterstedt had observed that the true *nigrita* of Fallén was none other than a damaged specimen of *Musca tempestiva* Fallén, a condition which he implied might be the cause for confusion concerning the identity of the species.

I have come to the opinion that the species named by Westwood as *nigrita* was probably in accordance with Macquart's views, since Westwood had cited Macquart as his authority for *Hydrophoria*. But owing to Zetterstedt's statement I am not inclined to believe that their species was Fallén's *nigrita*, though quite conceivably the same as *littoralis* and *vespertina*. In the light of such opposing evidence regarding the identity of *Musca nigrita* Fallén it seems to me advisable that any decision regarding the validity of Westwood's action for purposes of genotype fixation may well be postponed pending the results of further study.<sup>10</sup>

In 1877 Rondani selected *Anthomyia conica* Wiedemann to be genotype of *Hydrophoria*, a species linked by synonymy to *tibialis* (Macquart, 1835) and to *sagittariae* of the original series. This concept of the genus has been generally accepted, although in later years there has been a tendency to restrict its scope.

The genus *Zaphne* Robineau-Desvoidy (1830) has been treated as a synonym of *Hydrophoria* on the assumption that the two nominal species named in the genus were synonyms of *Anthomyia divisa* Meigen. The status of the group was revived by Coquillett (1910) in the designation of *divisa* as the genotype after considering the original forms *hylemyoidea* and *egerioidea* as conspecific. Acceptance of this synonymy seems to rest mainly on the fact that Macquart (1835) at an early date had regarded *hylemyoidea* as the same species as his *Hylemyia dispar*. With greater assurance authors have considered *dispar* to be identical with *divisa*.

In 1893 Pokorný established the monobasic genus *Acroptena* for the reception of the new form *A. simonyi*. Karl (1928) and Séguy (1937) have cited *Anthomyia divisa* Meigen as the type of *Acroptena*, a choice

<sup>8</sup>Westwood, J. O. Synopsis of the genera of British flies. In An introduction to the modern classification of insects, II, p. 142, 1840.

<sup>9</sup>Ringdahl, O. Bidrag till kännedomen om flugfaunaen (Diptera Brachycera) på Hallands Väderö. Ent. Tidskr., 62 (1-2): 22-23, 1941.

<sup>10</sup>In coming to these conclusions I should like to acknowledge the assistance of Dr. F. Van Emden, who has kindly communicated to me Mr. J. E. Collin's comments on the matter. In this, among other things, Mr. Collin has drawn my attention to Zetterstedt's explanation, of which I was not aware.

scarcely necessary in view of the monobasic character of the genus, and were it not for the fact that *divisa* had already been proposed by Coquillett as the genotype of *Zaphne*. The name *Acroptena* was early employed by Schnabl and Dziedzicki (1911) to denote those species not belonging to *Hydrophoria* in the strict sense, of which *divisa* may be regarded as one of the best known forms.

### EXPLANATION OF TERMS USED IN KEYS

The distance between the eyes is measured at the narrowest width of the frons; height of cheek at its narrowest; breadth of parafacial at its widest, when viewed in profile; length of arisal hairs implies the longest. The pronotal dorsocentral setae are the first pair of longish setulae on the dorsocentral planes of mesonotum.

The first abdominal tergum is considered as terga 1+2 owing to its connate structure, the fourth visible sclerite as tergum 5, and the abdominal tuft when present on tergum 4. The basal sclerites of the hypopygium are placed immediately cephalad of tergum 9. The latter is considered the anal sclerite. The processes refer to the male copulatory appendages of sternum 5.<sup>11</sup> The posteroventral surface of the hind femur is considered bare when devoid of all bristles except one which may be present at the extreme base and for any that may be present in the preapical region.

### KEY TO MALES OF NORTH AMERICAN HYDROPHORIA

1. Hypopleura with one or more hairs on upper margin. . . . . 2  
Hypopleura bare on upper margin. . . . . 12
2. Ninth tergum (anal sclerite) clothed exclusively with short uniformly developed setae which tend to become stouter mesad and caudad (ventrad), e. g., *frontata* (fig. 7). . . . . 3  
Ninth tergum clothed with diverse bristles and setae, the longest on dorsal region (cephalad), e. g., *divisa* (fig. 5). . . . . 8
3. Basal sclerites of hypopygium lightly and extensively dusted on dorsum (p. 271). . . . . *verticina*  
Basal sclerites largely polished on dorsum, at most with a small dusted area at dorsocentral region. . . . . 4
4. Basal sclerites of hypopygium bare, without bristles (p. 272). . . . . *polita*  
Basal sclerites having bristles. . . . . 5
5. Basal sclerites with a few setulae among the bristles, processes having a uniformly dense series or tuft of setulae on basal half of inner margin, outer surface of processes clothed for the greater part with fine slender setae, which are directed caudad. . . . . 6  
Basal sclerites with only three or four pairs of bristles, devoid of accessory setulae, processes with a dense fringe of setulae arising near middle of inner margin, which is extended weakly basad, outer surface of processes armed with fine erect bristles that are downwardly or outwardly directed (p. 272). . . . . *alpina*
6. Processes short and stoutish, rounded and broadened on apical region, inner marginal hairs situated basad as a tuft, arisal hairs barely as long as half width of third antennal segment (p. 274). . . . . *frontata*  
Processes tapering apicad, inner marginal hairs extending to beyond middle as a fringe, arisal hairs at least as long as half width of third antennal segment. . . . . 7

<sup>11</sup>Crampton, G. C. The terminal abdominal structures of male diptera. *Psyche*, 48 (2-3): 79-94, 2 pls., 1941.

7. Parafrontals contiguous in front of ocellus interrupting the interfrontalia, eyes separated by diameter of anterior ocellus, costal thorn as long as *r-m* cross vein, halteres yellow (p. 275) . . . . . **altilega**  
 Parafrontals narrowly separated by interfrontalia caudad, eyes separated by more than diameter of anterior ocellus, costal thorn inconspicuous, not as long as *r-m* cross vein, halteres blackish (p. 276) . . . . . **nigerrima**
8. Arisal hairs not longer than basal diameter of arista, upper anterior border of mesopleura with a weak bristle-like seta, cerci (superior forceps) extending apicad as a needle-like process between the gonostyli (inferior forceps), e. g., fig. 17 (p. 276) . . . . . **laticornis**  
 Arisal hairs about as long as width of third antennal segment, mesopleura lack a weak bristle-like seta on upper anterior border adjacent anterior notopleural bristle. . . . . 9
9. Mid tibia with no medial anteroventral bristle, posterior notopleural bristle with a few hairs at base (p. 278) . . . . . **divisa**  
 Mid tibia with a medial anteroventral bristle, posterior notopleural bristle devoid of hairs at base . . . . . 10
10. Marginal bristles of fifth abdominal tergum weakly developed, not longer than those on ninth tergum (anal sclerite), hind tibia with two postero-dorsal bristles, eyes separated by a distance about equal to width of third antennal segment, inner margin of processes with an inconspicuous fringe of short hairs (p. 279) . . . . . **proxima**  
 Marginal bristles of fifth tergum longer than those on ninth tergum, eyes separated by a distance less than width of third antennal segment, processes with a conspicuous fringe of longish setulae on inner margin. . . . . 11
11. Processes bent mesad at apex, gonostyli (inferior forceps) broad and plate-like, curved inward and pointed at apex, anal cleft extending three-quarters length of ninth tergum, thus nearly dividing the sclerite in two (p. 280) . . . . . **katmaiensis**  
 Processes not bent mesad at apex, gonostyli slender and geniculate, anal cleft reduced to small proportions, scarcely reaching beyond middle of sclerite (p. 282) . . . . . **brunneifrons**
12. Tergum 4 tufted below . . . . . 13  
 Tergum 4 not tufted below, at most with a dense series of longish bristles along lateral border. . . . . 18
13. Fifth fore-tarsal segment armed with a stoutish bristle, fourth fore-tarsal segment longer than third, mid femur with posteroventral bristles scarcely longer than apical setulae, hind femur with posteroventral surface bare except for apical and basal bristles (p. 283) . . . . . **wierzejskii**  
 Fifth fore-tarsal segment not armed with a stoutish bristle, second, third and fourth fore-tarsal segments successively shorter, mid femur with longish posteroventral bristles. . . . . 14
14. Tergum 4 sharply narrowed laterad (ventrad) by infolding of integument so that lateral margin appears less than half as long as that of tergum 3. . . . . 15  
 Tergum 4 not sharply narrowed laterad by infolding of integument, lateral margin of tergum 4 appears longer than half length of that of tergum 3 (p. 284) . . . . . **borealis**
15. Longest bristles in abdominal tuft equal to or more than three-quarters length of hind tibia, prealar bristle longer than posterior notopleural bristle, arisal hairs scarcely as long as basal diameter of arista. . . . . 16  
 Longest bristles of abdominal tuft not more than half length of hind tibia, prealar bristle shorter than posterior notopleural bristle. . . . . 17
16. Tuft arising on basal third of ventral surface of abdomen (p. 286) . . . . . **lucidiventris**  
 Tuft arising at about middle of ventral surface of abdomen (p. 286), . . . . . **alaskensis**
17. Arisal hairs fully as long as half width of third antennal segment, scutellum and mesonotum grayish pruinose, the latter with three distinct vittae, *m-cu* cross vein markedly sinuate, directed in a plane which if extended cephalad would intersect costa at point of union with  $R_{2+3}$  (p. 287), . . . . . **implicata**  
 Arisal hairs not as long as half width of third antennal segment, scutellum and mesonotum largely blackish and shining, with little trace of pruinoscence, *m-cu* cross vein lying in a plane which if extended cephalad would intersect costa proximad of union with  $R_{2+3}$  (p. 288) . . . . . **fasciculata**

18. Marginal bristles of fifth abdominal tergum weakly developed, not longer than those on ninth tergum, upper anterior border of mesopleura with no weak bristle-like setae (p. 279)..... **proxima**  
 Marginal bristles of fifth tergum well developed, longer than those on ninth tergum, mesopleura invariably with one or more weak bristle-like setae on upper anterior border adjacent anterior notopleural bristle..... 19
19. Mid tibia with no medial anteroventral bristle, arista pectinate, hairs as long as width of third antennal segment, hind tibia more or less brownish tinged, paler than femora..... 20  
 Mid tibia with a medial anteroventral bristle, arista hairs shorter than width of third antennal segment, hind tibia blackish, concolorous with femora..... 22
20. Prealar bristle long, calyptrae and basal region of wings densely yellowish, large species, 7-9 mm. (p. 288)..... **conica**  
 Prealar bristle shorter than posterior notopleural bristle, wings and calyptrae not densely yellowish, smaller species, 6 mm..... 21
21. Parafacials at base of antennae as wide as breadth of third antennal segment, hind tibia with a bristle on proximal half of posterior surface, abdomen blackish (p. 290)..... **galeata**  
 Parafacials narrower than breadth of third antennal segment, hind tibiae with no bristle on proximal half of posterior surface, abdomen yellowish tinged basad (p. 291)..... **ruralis**
22. Arista hairs scarcely longer than basal diameter of arista..... 23  
 Arista hairs at least as long as half width of third antennal segment..... 24
23. Ninth tergum (anal sclerite) enlarged and subglobose, expanding dorsad above plane of tergum 5, processes devoid of longish bristles, prealar bristle as long as anterior notopleural bristle, mid tibia usually with two anterodorsal bristles (p. 292)..... **zetterstedti**  
 Ninth tergum not raised above plane of tergum 5, not proportionately abnormal in size, processes armed on outer border with a few long slender bristles, prealar bristle shorter than anterior notopleural bristle, mid tibia usually with one anterodorsal bristle (p. 276)..... **laticornis**
24. Ninth tergum appressed when viewed from above, and clothed with fine setulae which become longer and denser caudad (ventrad), middle bristles of marginal series on tergum 5 set much further from caudal margin than is the case on tergum 4, chitin along caudal border of tergum 5 extensively membranous, hind tibia with one or two short bristles on posteroventral and posterior surfaces proximad, processes devoid of bristles except basad near inner margin (p. 292)..... **seticauda**  
 Ninth tergum clothed with bristles and setulae which become longer cephalad (dorsad), marginal series of bristles on terga 4 and 5 about same distance from respective margins, chitin along caudal border of tergum 5 narrowly membranous at most..... 25
25. Eyes separated by not more than distance between posterior ocelli exclusive, if wider costal thorn minute, not longer than breadth of costa, processes slender and armed along entire outer surface with long curling bristles and setulae directed mesad, and which become longer distad, mid tibia with no preapical mid dorsal bristle, posterior notopleural bristle bare at base (p. 294)..... **uniformis**  
 Eyes separated by a distance at least equal to that between posterior ocelli, if narrower costal thorn longer than width of costa, processes broad, setulose, weakly bristled..... 26
26. Mid femur with posteroventral bristles uniformly short, not as long as breadth of femur where situated, anteroventral surface with no bristle basad, hind femur usually with no bristles on posteroventral surface except at extreme base and at apex, occasionally with a short bristle at middle, fore tibia with preapical anterodorsal bristle setulose (p. 295),  
**ignobilis**  
 Mid and hind femora with a series of longish posteroventral bristles exceeding in length width of femur where situated, fore tibia with a longish preapical anterodorsal bristle..... 27

27. Thorax with one or more pairs of weak bristle-like presutural acrosticals, setulae along cephalic border of mesonotum coarse and spinulose, dorso-central marks of abdomen becoming conspicuously narrower caudad with each successive segment (p. 296)..... **ambigua**  
 Presutural acrosticals uniformly setulose, setulae along cephalic border of mesonotum fine, dorsocentral marks on abdominal segments 3, 4 and 5 of nearly equal proportions (p. 297)..... **flavohalterata**

## KEY TO FEMALES OF NORTH AMERICAN HYDROPHORIA

1. Hypopleura with one or more setulae on upper margin..... 2  
 Hypopleura bare on upper margin..... 12
2. Mid tibia without medial anteroventral bristle, posterior notopleural bristle with a few setulae at base, ventral bristle of caudal pair of sternopleurals not longer than half length of dorsal bristle, (p. 278)..... **divisa**  
 Mid tibia with a medial anteroventral bristle, posterior notopleural bristle bare at base, ventral bristle of caudal pair of sternopleurals longer than half length of dorsal bristle..... 3
3. Hind tibia with two posterodorsal bristles, presutural acrosticals in two closely placed series and slightly stronger than adjacent setulae, with few interserial setulae, marginal bristles of tergum 5 weak, the middle bristles and those on discal surface scarcely longer than adjacent setulae (p. 279), **proxima**  
 Hind tibia with three or more posterodorsal bristles, middle bristles of marginal series on tergum 5 well developed, presutural acrosticals in two well separated series, setulose and with numerous interserial setulae... 4
4. Parafrontals broad and setulose, setulae as long as those on ocellar callosity, upper anterior border of mesopleura devoid of weak bristle-like setae, arisal hairs longer than basal diameter of arista..... 5  
 Parafrontals restricted in width and having at most only a few inconspicuous setulae which are not half as long as those on ocellar callosity, mesopleura with a weak bristle-like seta on upper anterior border adjacent anterior notopleural bristle, arisal hairs not as long as basal diameter of arista (p. 276)..... **laticornis**
5. Mid and hind tibiae blackish, terminal sclerites of ovipositor devoid of fine recurrent spinules..... 6  
 Mid and hind tibiae yellowish, terminal sclerites of ovipositor armed with a few fine recurrent spinules..... 11
6. Mid tibia with two anterodorsal bristles, both of which are longer than greatest diameter of mid tibia (p. 271)..... **verticina**  
 Mid tibia with one anterodorsal or if with two such bristles the shorter one not longer than greatest diameter of tibia..... 7
7. Grayish species, mesonotum and scutellum pale gray, veins yellowish brown on basal region of wings (p. 272)..... **polita**  
 Blackish species, scutellum and mesonotum brownish black, veins blackish brown on basal region of wings..... 8
8. Frons with a loose inner series of erect slender setulae accompanying parafrontal bristles, mesonotum with coarse spinulose setulae along cephalic border (p. 276)..... **nigerrima**  
 Parafrontals lacking an inner series of erect slender setulae accompanying the bristles, mesonotum with normal slender setulae along cephalic border..... 9
9. Arisal hairs at least as long as half width of third antennal segment, tergum 5 clothed with erect bristles and setulae of nearly equal length, marginal bristles shorter than length of tergum 5 along dorsocentral plane (p. 275)..... **altilega**  
 Arisal hairs scarcely as long as half width of third antennal segment, tergum 5 clothed with diverse bristles and setulae, not of uniform character, marginal bristles as long as tergum 5 at dorsocentral plane..... 10
10. Knob of halteres yellow, hind femur with two preapical posterodorsal bristles (p. 272)..... **alpina**  
 Knob of halteres purplish, hind femur with one preapical posterodorsal bristle (p. 274)..... **frontata**



11. Fore tibia largely reddish yellow on proximal half, frontal vitta entirely blackish or largely reddish, caudal region being sometimes purplish tinged, veins yellowish on basal region of wings (p. 280)..... **katmalensis**  
Fore tibia largely infuscated on proximal region, frontal vitta with a reddish patch at base of antennae, blackened caudad, veins brownish on basal region of wing (p. 282)..... **brunneifrons**
12. Mid tibia with no medial anteroventral bristle, caudal pair of ocellar bristles widely divergent and directed outwards, arista pectinate..... 13  
Mid tibia with a medial anteroventral bristle, caudal pair of ocellar bristles narrowly divergent and directed forward..... 15
13. Prealar bristle long, calyptrae and basal region of wings densely yellowish, ventral bristle of caudal pair of sternopleurals long and strong, large species, 7 mm. (p. 288)..... **conica**  
Prealar bristle shorter than posterior notopleural bristle, calyptrae and basal region of wings hyaline, ventral bristle of caudal pair of sternopleurals short and weak, smaller species, 5 mm..... 14
14. Marginal bristles on tergum 5 finely developed, not stronger than those on disc, abdominal vitta not noticeably broadened on terga 1+2, and 3, distal half of proboscis normal in proportions (p. 290)..... **galeata**  
Marginal bristles on tergum 5 robust, stronger than discal bristles, abdominal vitta broadly band-like on terga 1+2 and 3, distal half of proboscis notably shortish and stout, abdomen sometimes with trace of yellowish testaceous basad (p. 291)..... **ruralis**
15. Hind femur usually with no bristles on posteroventral surface except for normal basal and preapical bristles..... 16  
Hind femur with one or more bristles on posteroventral surface in addition to basal and preapical bristles..... 20
16. Prealar bristle as long as anterior notopleural bristle, calyptrae and basal region of wings densely yellowish, mid tibia with two anterodorsal bristles, both longer than anteroventral, aristal hairs scarcely longer than aristal diameter at base (p. 292)..... **zetterstedti**  
Prealar bristle shorter than anterior notopleural bristle, calyptrae and wings not densely yellowish, mid tibia with one anterodorsal bristle or if two the proximal bristle not longer than anteroventral, aristal hairs longer than basal diameter of arista..... 17
17. Abdomen and scutellum black with only slight pruinescence, costal thorn prominent and as long as humeral cross vein..... 18  
Abdomen and scutellum grayish and pruinulent, costal thorn weak and inconspicuous, shorter than humeral cross vein..... 19
18. Ventral bristle of caudal pair of sternopleurals longish, nearly equal to length of dorsal bristle, presutural acrosticals with one or two pairs of fine bristle-like setae that are stronger than adjacent setulae, mesonotum with no coarse spinules along cephalic border (p. 292)..... **seticauda**  
Ventral bristle of caudal pair of sternopleurals shortish, about half length of upper bristle, presutural acrosticals setulose, not stouter than adjacent setulae, mesonotum with a series of coarse erect spinules along cephalic border (p. 295)..... **ignobilis**
19. Posterior notopleural bristle with one or more setulae at base, costa and veins yellowish on basal region of wing (p. 283)..... **wiérzejakii**  
Posterior notopleural bristle bare at base, costa and veins brownish on basal region of wings (p. 287)..... **implicata**
20. Prealar bristle as long as anterior notopleural bristle, if slightly shorter the aristal hairs scarcely longer than aristal diameter at base..... 21  
Prealar bristle shorter than anterior notopleural bristle..... 23
21. Basal region of wings and calyptrae intensively yellowish, mid tibia with two anterodorsal bristles, both as long as anteroventral bristle (p. 292), **zetterstedti**  
Basal region of wings not intensively yellowish, veins at least brownish in comparison with calyptrae, mid tibia with one anterodorsal bristle, if two the proximal bristle not as long as anteroventral..... 22
22. Costal thorns proportionately longish, equal to length of humeral cross vein, ovipositor armed with fine recurrent spinules on terminal sclerites, smaller species, 5 mm. (p. 286)..... **lucdiventris** and **alaskensis**

- Costal thorns proportionately short and inconspicuous, shorter than humeral cross vein, terminal sclerites of ovipositor with no recurrent spinules, larger species, 6.5 mm. (p. 276)..... **laticornis**
23. Presutural acrosticals with one or more pairs of weak bristles..... 24  
Presutural acrosticals setulose, with no bristle-like setae that are comparable in development to pronotal dorsocentral setae..... 26
24. Mesonotum and abdominal terga largely blackish and shiny, concolorous with femora, dorsocentral vitta poorly defined, scutellum almost entirely blackish (p. 292)..... **seticauda**  
Mesonotum and abdominal terga grayish, paler than femora, dorsocentral vitta well marked, scutellum with distinctive paler areas laterad of dorsocentral marking..... 25
25. Mid tibia with mid dorsal preapical bristle lacking, posterior notopleural bristle with no setulae near base (p. 294)..... **uniformis**  
Mid tibia with mid dorsal preapical bristle present, posterior notopleural bristle with one or more setulae near base (p. 296)..... **ambigua**
26. Arisal hairs not longer than basal diameter of arista, terminal sclerites of ovipositor with no fine recurrent spinules (p. 276)..... **laticornis**  
Arisal hairs longer than basal diameter of arista, anal sclerites armed with fine recurrent spinules..... 27
27. Parafacials conspicuously narrowed ventrad when viewed in profile, width at narrowest not exceeding half that at base of antennae, posterior notopleural bristle devoid of basal setulae, mid tibia usually lacking a bristle at apex of mid dorsal surface (p. 294)..... **uniformis**  
Parafacials at most only slightly narrowed ventrad, narrowest width exceeding half that at base of antennae, posterior notopleural bristle usually with one or more setulae near base, mid tibia with a bristle at apex of mid dorsal surface..... 28
28. Abdominal terga conspicuously grayish pruinose, head higher than long when viewed in profile, larger species, 6 mm. (p. 296)..... **ambigua**  
Abdominal terga black, with only trace of light pruinescence, head squarish in profile, almost as long as high, smaller species, 5 mm..... 29
29. Ovipositor with dorsal sclerites entirely polished, bristles on anteroventral surface of hind femur continued basad as stoutish bristles (p. 297)..... **flavohalterata**  
Ovipositor with caudal region of dorsal sclerites largely dull and opaque, bristles on proximal region of anteroventral surface of hind femur usually weaker and finer developed than those distad..... 30
30. Abdominal terga largely with shiny polished reflections, arisal hairs scarcely much longer than basal diameter of arista (p. 288)..... **fasciculata**  
Abdominal terga largely with traces of pruinescence, arisal hairs at least twice as long as basal diameter of arista (p. 284)..... **borealis**

### *Hydrophoria verticina* (Zetterstedt)

Figures 9, 19, 42

*Anthomyia verticina* Zetterstedt, Insect Lapp., p. 665, 1838.

*Aricia verticina* Stem, Ent. Nachr., 18 (21-22): 324, 1892

*Hydrophoria arctica* Malloch, Rept. Can. Arct. Exped., 1913 16. III, Pt. C, p. 69C, 1919; Malloch, Can. Ent., 52: 254, 256, 1920; Séguy, Gen. Insect., Fasc. 205, p. 132, 1937.

*Acroptenu verticina* Ringdahl, K. Svensk. Vetenskap. Skrift. Naturskyddsarenen, Nr. 18, p. 18, 1931; Collin, Ann. Mag. Nat. Hist., ser. 10, 7: 84, 1931; Ringdahl, Ent. Tidskr., 53 (3): 174, 1931; Ringdahl, Opusc. entom., 4 (3-4): 145, 1939

*Hydrophoria verticina* Séguy, Gen. Insect., Fasc. 205, p. 134, 1937.

Ringdahl (1939) has drawn attention to the fact that until recently *verticina* has been confused with *frontata*. Stein (1907) recorded the species as a synonym of the latter. The male of *verticina* may be distinguished from that of *frontata* by having the dorsum of the basal sclerites of the hypopygium extensively dusted (not largely polished),

the processes tapering distad (not rounded and truncate), and in common with the female has two robust anterodorsal bristles on the mid tibia.

*Material Examined*.—*Colorado*: ♀, Fall River Pass, 10,500 ft. alt., VIII.23.36. *Greenland*: ♀, Hekla Havn, VI.18.92 (Deichmann) [U. S. N. M.]. *Manitoba*: 12 ♂, 2 ♀, Churchill, VIII.2-9.37; ♂, Churchill River, 20 mi. S. of Churchill, VIII.5-6.37 (R. H. Daggy and D. G. Denning) [F. M. Snyder]. *Wyoming*: ♂, Medicine Bow, VIII.19.36 (C. J. Sorenson) [F. M. Snyder.]

### *Hydrophoria polita* Malloch

*Hydrophoria polita* Malloch, Trans. Amer. Ent. Soc., 46: 170, 1920; Malloch, Can. Ent., 52: 254, 256, 1920; Frison, Bull. Ill. Nat. Hist. Surv., 16 (4): 200, 1927; Séguy, Gen. Insect., Fasc. 205, p. 134, 1937.

This species belongs to the *frontata* segregate. The male may be distinguished from related forms by the absence of bristles on the basal sclerites of the hypopygium, and by their entirely polished surface. The processes when viewed in profile appear broad basad and taper rapidly distad. The arisal hairs attain a length fully equal to three-quarters of the width of the third antennal segment.

*Material Examined*.—*Colorado*: ♂, Tennessee Pass, 10,500 ft. alt., VIII.6-8.20 [A. M. N. H.]. *Montana*: ♂, Georgestown Lake, VII.31.23 (A. L. Melander).

### *Hydrophoria alpina* new species

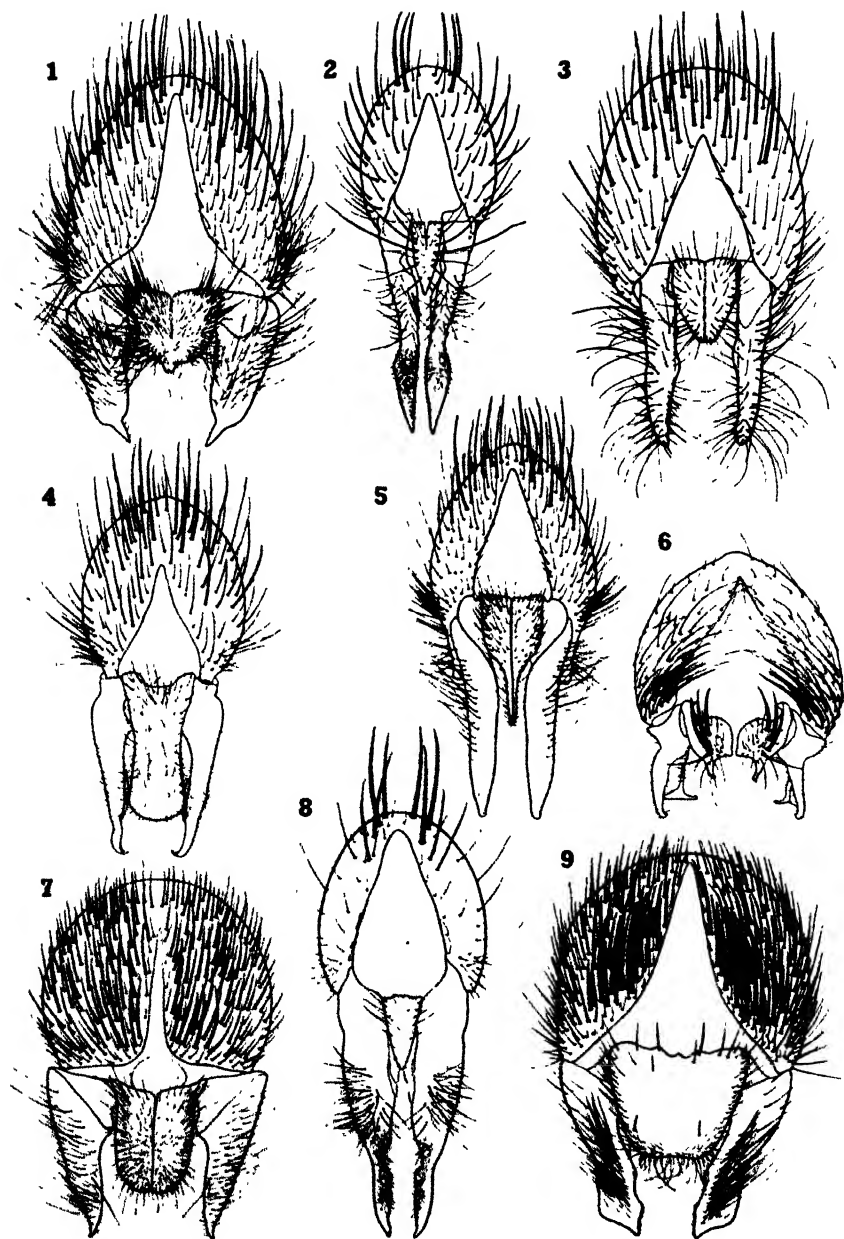
*Male*.—Black, similar in appearance and bristling to *frontata*, parafacials and cheeks densely pruinescent, basal sclerites of hypopygium entirely polished, wings faintly tinged, calyptrae white, halteres yellow, with trace of purplish tinge.

Interfrontalia complete to ocellus, longest hairs of arista about twice as long as basal diameter of arista, basal sclerites of hypopygium with three or four pairs of bristles and devoid of additional setulae, abdominal sterna 1 to 4 broad and densely setulose, processes truncate at apex and curved inward, armed at middle of inner margin with a loose tuft of longish setulae, the latter extending basad in a sparse series, outer surface clothed with fine erect bristles that are directed outward and ventrad. Mid tibia with one medial anterodorsal bristle, hind femur with bristles on proximal half of antero- and posteroventral surfaces noticeably finer than those distad, each series becoming denser and confused owing to the presence of additional erect longish setulae on proximal region.

*Female*.—Cheeks about half as high as height of eye, parafrontals densely brownish infuscated, and with only slight trace of shiny

### EXPLANATION OF PLATE I

Dorsal (caudal) aspect of male copulatory appendages. Fig. 1. *Hydrophoria kalmiensis* Malloch. 2. *H. conica* (Wiedemann). 3. *H. proxima* Malloch. 4. *H. brunneifrons* (Zetterstedt). 5. *H. divisa* (Meigen). 6. *H. seticauda* Malloch. 7. *H. frontata* (Zetterstedt). 8. *H. ruralis* (Meigen). 9. *H. verticina* (Zetterstedt).



reflections; abdomen with distinct pale grayish pruinescence, paler than mesonotum; parafacials viewed from above with a broad pruinose fascia at base of antennae, in width at least equal to that of third antennal segment; fore tibia with a robust apical posterodorsal bristle, mid tibia with or without a weaker bristle basad of anterodorsal, hind femur with a second preapical posterodorsal bristle, posteroventral series of bristles extending to apex. Length 6 mm.

*Holotype*, ♂, Mt. Washington, New Hampshire, no date, (Mrs. A. T. Slosson) [N. E. M. N. H.]. *Allotype*, Mt. Washington, Alpine Garden, New Hampshire, VIII. 16. 16 (C. W. Johnson) [N. E. M. N. H.]. Paratypes, 2 ♀, White Mts., New Hampshire; ♀, Mt. Washington, New Hampshire, no dates, (Morrison) [U. S. N. M.].

The type specimen has Malloch's label bearing the name *Hydrophoria arctica* Mall., and as such the species has been recorded in Johnson's (1925) list of New England diptera. Later Malloch (1934) regarded *arctica* as probably identical with *frontata*. I have considered this specimen as well as others from the vicinity of Mt. Washington as distinct from those representing *frontata* on the basis of differences in the bristling of the processes and the basal sclerites of hypopygium, as indicated in the key to males. In both sexes of *alpina* the cheeks are slightly broader than in *frontata* and the halteres are invariably yellow.

### *Hydrophoria frontata* (Zetterstedt)

Figures 7, 23, 41

*Anthomyza frontata* Zetterstedt, Insect. Lapp., p. 609, 1838.

*Arica frontata* Zetterstedt, Dipt. Scand., 4: 1453, 1845; Holmgren, K. Vet. Akad. Handl., 8 (5): 33, 1869; Siebke, Enum. Insect. Norveg., 4: 107, 1877; Stein, Ent. Nachr., 18 (21-22): 324, 1892.

*Anthomyia frontata* Staeger, Krøyer's Naturhist. Tidsskr., n. ser. I, p. 363, 1845; Schiødt, Naturhist. Tillaeg til Rink, p. 69, 1857.

*Scatomyza obscura* Boheman, Oefv. K. Vet. Akad. Förhandl., 22: 573, 1805.

*Hylemyia frontata* Osten Sacken, Smithsn. Misc. Coll., 3: 167, 1878; Lundbeck, Vidensk. Medd. Naturh. Foren. Kbhvn., 1: 313, 1898; Aldrich, Misc. Coll. Smithson. Inst., 46 (1444): 552, 1905.

*Hylemyia spinulunus* Pandellé, Rev. ent. France, 18: 220, 1900.

*Hydrophoria sopulicauca* Strobl, Mitt. Ver. Steiermark, 46: 45, 168, 1910.

*Acroptena frontata* Henriksen and Lundbeck, Grönlands Landarthropoder, p. 638, 1917; Ringdahl, Ent. Tidsskr., 39 (2): 187, 1918; Collin, Ann. Mag. Nat. Hist., ser. 9, 11: 117, 1923; Collin, Ann. Mag. Nat. Hist., ser. 9, 14: 201, 205, 1924; Ringdahl, Trömsö Museums Arshefter, (1926), 49 (3): 35, 1928; Collin, Ann. Mag. Nat. Hist., ser. 10, 7: 83, 1931; Ringdahl, K. Svensk. Vetenskaps. Skrift. Naturskyddsärenden, Nr. 18, p. 18, 1931; Ringdahl, Skrift. om Svalbard og Ishavet, No. 53, p. 16, 1933; Longstaff, Ann. Mag. Nat. Hist., ser. 10, 18: 532, 1936; Carpenter and Holm, Ann. Mag. Nat. Hist., ser. 11, 3: 71, 1939; Ringdahl, Opusc. entom., 4 (3-4): 141, 1939.

*Hydrophoria frontata* Ségué, Gen. Insect., Fasc. 205, p. 133, 1937.

The species *frontata* is typical of a group within the genus which in the male has the ninth tergum (anal sclerite) clothed with a characteristic vestiture of short setae. In fact it seems that the name *frontata* has been used mistakenly in much of the literature for species belonging to this group, largely on account of the possession of this striking character in the males (Ségué 1937). This vestiture may be weak or stout,

dense or sparse, according to species, but conforming to a general distinctive pattern, e. g., in *frontata*, *verticina*, *arctica*, *polita*, *nigerrima*, *packardii*, *alpina*, the European form *Acroptena simonyi* Pokorný and the Siberian species *A. tundrica* Schnabl. The male of *frontata* has the processes short and stout, blunt and rounded at the apex, with a few weak setulose bristles directed apicad, and having a dense tuft-like series of fine setulae on the basal region of the inner margin. The basal sclerites of the hypopygium are polished except for a trace of pruinescence on the dorsocentral plane. In both sexes the arisal hairs are about equal to twice the basal diameter of the arista, and the knobs of the halteres are invariably purplish, not black as is typical of *nigerrima*.

*Material Examined*.—*Baffin Island*: 4 ♂, ♀, Clyde River, IX.15.35 (W. J. Brown) [C. N. C.]. *Greenland*: ♂, Hekla Havn, August 1891, ♀, same locality, VI.11.92, (Deichmann); ♀, Fiskenas, VII 1 89 (Lundbeck) [U. S. N. M.].

### *Hydrophoria altilega* new species

*Male*—Similar in habitus to *verticina*, but differing in having basal sclerites of hypopygium almost entirely polished, bristles of ninth tergum less stiffly formed, cerci cordate and densely setulose, processes of fifth sternum tapered distad and fringed along greater part of inner margin with a dense series of setulae. Eyes separated by a distance comparable to diameter of anterior ocellus, parafrontals contiguous caudad; parafrontal, vibrissal and genal bristles robust, arisal hairs fully as long as half width of third antennal segment. Prealar bristle short, sternopleurals arranged 2 : 2, hypopleura with hairs on upper margin. Mid tibia with two anterodorsal bristles in type. Costal thorn as long as *m-cu* cross vein, halteres yellow.

*Female*. Parafrontals broad and densely setulose, fifth abdominal tergum with discal bristles and setulae less differentiated than in *verticina*, marginal bristles weakly developed. Terminal sclerites of ovipositor without recurrent spinules. Mid tibia with one anterodorsal bristle. Halteres purplish tinged. Length 7 mm.

*Holotype*, ♂, Hedley, British Columbia, VIII 29 23 (C. B. D. Garrett) [C. N. C.]. *Allotype*, ♀, Trail Ridge Pass, Colorado, 12,100 ft. alt., VIII.23.36 (F. M. Snyder) [C. N. C.].

Until recently I had regarded this species as identical with Malloch's *arctica*, but Mr. Brooks of the Division of Entomology at Ottawa, who has kindly compared specimens with type of *arctica*, has informed me that *arctica* agrees in all essential respects with *verticina*, even to the pollinose character of the basal sclerites of the hypopygium, which is not to be inferred from the description of *arctica*. In the male of *altilega* the basal sclerites of the hypopygium are largely polished across the dorsum, and the bristles on the anal sclerite are less coarsely developed than in *verticina*; the cerci are cordate and densely setulose, not quadrate and largely bare as in *verticina*. In the female of *altilega* the bristles and setulae of the fifth abdominal tergum are less diverse in character, and are erect.

**Hydrophoria nigerrima** Malloch

*Hydrophoria nigerrima* Malloch, Trans. Amer. Ent. Soc., 46: 169, 1920; Malloch, Can. Ent., 52: 253, 255, 1920; Frison, Bull. Ill. Nat. Hist. Surv., 16 (4): 200, 1927; Séguy, Gen. Insect., Fasc. 205, p. 133, 1937.

This species belongs to the *frontata* segregate. In typical specimens the knobs of the halteres are black (not purplish), and the abdomen is deep black and almost devoid of pruinescence. The longest hairs of the arista are over half as long as the width of the third antennal segment, whereas in *frontata* and *verticina* these are scarcely equal to half the width of the third antennal segment. In *nigerrima* the parafrontal bristles are accompanied by an inner series of noticeably long fine setulae, and in the male the processes taper distad, not being blunt or rounded as in *frontata*.

**Material Examined.**—*Washington*: ♂, ♀, Mt. Rainier, 7,000–9,000 ft. alt., on snow, August 1917 (A. L. Melander), holotype and allotype [U. S. N. M.]. ♀, same locality and data as for holotype, paratype [Mont. Exp. Station]. ♂, ♀, Mt. Rainier, Paradise Park, August 1917, paratypes, (A. L. Melander).

**Hydrophoria laticornis** (Ringdahl)

Figures 17, 28, 51

*Acroptena laticornis* Ringdahl, Ent. Tidskr., 37 (3-4): 236, 1916; Ringdahl, Ent. Tidskr., 39 (2): 188, 1918; Ringdahl, K. Svensk. Vetenskaps. Skrift. Naturskyddsaren, Nr. 18, p. 18, 1931; Séguy, Gen. Insect., Fasc. 205, p. 133, 1937.

*Hydrophoria congrua* Malloch, Ohio Jour. Sci., 20 (7): 271, 1920; Malloch, Can. Ent., 52: 255, 1920; Séguy, Gen. Insect., Fasc. 205, p. 133, 1937.

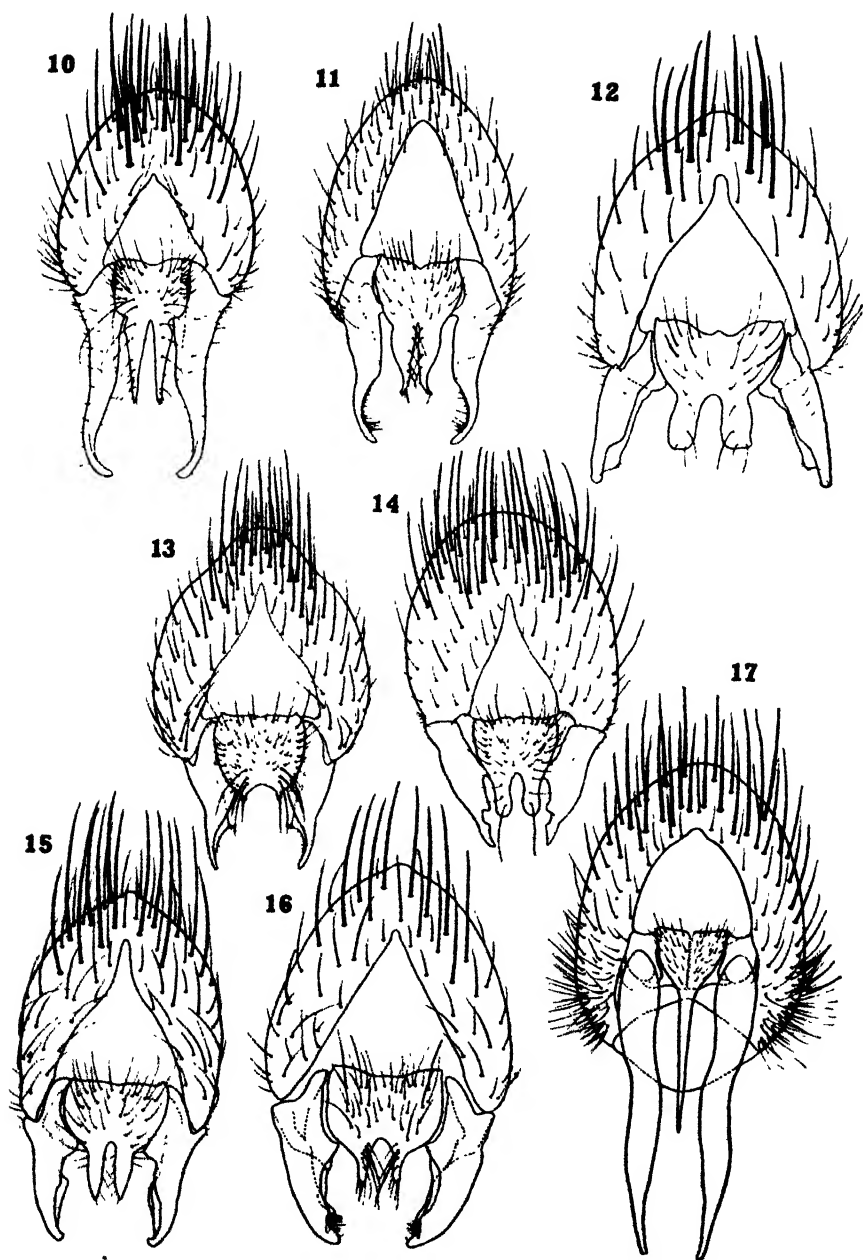
*Hydrophoria laticornis* Séguy, Gen. Insect., Fasc. 205, p. 133, 1937.

This species has the arista minutely haired, nearly bare as in *zetterstedti*, from which it may be distinguished by the slightly shorter prealar bristle and in having only one anterodorsal bristle on the mid tibia. In the male of *laticornis* the cerci (superior forceps) are prolonged as a firm needle-like process between the gonostyli (inferior forceps), and the processes bear a few significant longish bristles on the outer surface. In the female the anal palpi of the ovipositor are devoid of spinules, and not uncommonly the mid femur has a stoutish bristle toward the base of the anteroventral surface. In both sexes I have found occasional specimens with a single hair on the upper margin of the hypopleura.

**Material Examined.**—*Alaska*: ♂, Anchorage, VI 6.17 (J. S. Hine). *Alberta*: ♂, 2 ♀, Elk Island, V 16.37 (E. H. Strickland); ♀, Banff, VI 3.22, ♀, same locality, VI 1.22 (C. B. D. Garrett) [C. N. C.]. *Manitoba*: ♂, Aweme, V 27.24 (N. Criddle). *Minnesota*: ♂, Itasca Park, V 24.28, ex larch sawfly cocoons, (L. W. Orr). *Ontario*: 3 ♀, Low Bush, Lake Abitibi, VI 4–7.25 (N. K. Bigelow); ♀, Miners' Bay, V 26.27 (F. P. Ide).

## EXPLANATION OF PLATE II

Dorsal (caudal) aspect of male copulatory appendages. Fig. 10. *Hydrophoria ambigua* (Fallén). 11. *H. wierzejskii* (Mik). 12. *H. ignobilis* (Zetterstedt). 13. *H. borealis* Malloch. 14. *H. zetterstedti* (Ringdahl). 15. *H. lucidiventris* (Zetterstedt). 16. *H. fusciculata* (Schnabl). 17. *H. laticornis* (Ringdahl).





***Hydrophoria divisa* (Meigen)**

Figures 5, 30, 48

- Anthomyia divisa* Meigen, Syst. Besch., 5: 99, 1826.  
*Hydrophoria nymphiae* Robineau-Desvoidy, Essai Myod., 504, 1830; Macquart, Hist. Nat. Ins., 2: 300, 1835.  
*Hydrophoria trapae* Robineau-Desvoidy, Essai Myod., 505, 1830.  
*Hydrophoria nymphaeicola* Robineau-Desvoidy, Essai Myod., 506, 1830.  
*Zaphne hylemyoidea* Robineau-Desvoidy, Essai Myod., 527, 1830.  
*Zaphne egerioidea* Robineau-Desvoidy, Essai Myod., 527, 1830.  
*Hylemyia dispar* Macquart, Hist. Nat. Ins., 2: 317, 1835.  
*Hylemyia divisa* Meigen, Syst. Besch., 7: 315, 1838; Meade, Ent. Month. Mag., 18: 102, 1881; Meade, Descr. List Brit. Anth., 1: 30, 1897; Pandellé, Rev. ent. France, 18: 215, 1899.  
*Aricia ambigua* Zetterstedt p. p., Dipt. Scand., 4: 1415, 1845.  
*Anthomyza coronata* Zetterstedt, Dipt. Scand., 4: 1658, 1845; Zetterstedt, Dipt. Scand., 14: 6275, 1860.  
*Aricia divisa* Zetterstedt, Dipt. Scand., 12: 4723, 1855.  
*Hylemyia coronata* Schiner, Faun. Austr., 1: 631, 1862; Bidentk, Ent. Tidskr., 13: 243, 1892.  
*Spilogaster divisa* Mik, Verh. zool.-bot. Ges. Wien, 17: 422, 1867; Neuhaus, Dipt. March., p. 215, 1886; Lundbeck, Vidensk. Medd. Naturh. Foren. Kbhvn., 1: 309, 1898.  
*Hydrophoria divisa* Meade, Ent. Month. Mag., 18: 102, 1881; Stein, Ent. Nachr., 14 (24): 376, 1888; Strobl, Verh. zool.-bot. Ges. Wien, 18: 243, 1893; Stein, Berl. Ent. Zeitschr., (1897), 42 (3-4): 208, 1898; Aldrich, Misc. Coll. Smithsn. Inst., 46 (1444): 551, 1905; Stein, Kat. Paläark. Dipt., 3: 685, 1907; Smith, Ann. Rept. N. J. State Museum 1909, p. 791, 1910; Malloch, Trans. Amer. Ent. Soc., 44: 297, 1918; Malloch, Can. Ent., 52: 254, 256, 1920; Cole and Lovett, Proc. Cal. Acad. Sci., 11 (15): 312, 1921; Hockett, Mem. 77, N. Y. (Cornell) Agr. Exp. Sta., (1923), p. 15, 1924; Johnson, Insect Faun. Biol. Surv. Mt. Desert Region, p. 210, 1927; Séguy, Gen. Insect., Fasc. 205, p. 133, 1937; Strickland, Can. Jour. Research, Sect. D, 16: 209, 1938.  
*Anthomyza dignota* Bidentk, Entom. Tidskr., 11: 199, 1890.  
*Acroptena divisa* Schnabl and Dziedzicki, Abh. K. Leop.-Carol. Deutsch. Akad. Naturforsch., 95 (2): 103, 1911; Stein, Arch. f. Naturgesch., (1913), 79 A (8): 31, 1915; Stein, Arch. f. Naturgesch., (1915), 81 A (10): 134, 1916; Henriksen and Lundbeck, Grönlands Landarthropoder, p. 639, 1917; Ringdahl, Ent. Tidskr., 39 (2): 187, 1918; Stein, Arch. f. Naturgesch., (1918), 84 A (9): 74, 1920; Séguy, Faune de France, 6: 146, 1923; Karl, Tierwelt Deutschlands, 13 (3): 120, 1928; Collin, Ann. Mag. Nat. Hist., ser. 10, 7: 84, 1931; Ringdahl, K. Svensk. Vetensk. Skrift. Naturskyddsårnden, Nr. 18, p. 18, 1931; Tiensuu, Acta Soc. Faun. Flor. Fenn., 58 (4): 32, 1935.

This species is widely distributed in North America. It may be readily distinguished from among those species with hairs on the upper margin of the hypopleura by the lack of a medial anteroventral bristle on the mid tibia and by the possession of setulae at the base of the posterior notopleural bristle.

**Material Examined.**—*Alaska*: ♂, Savonoski, Naknek Lake, VIII. 1.19; ♂, Katmai, no date, (J. S. Hine); ♀, Fairbanks, VII. 3.21; ♀, Healy, VII. 7.21 (J. M. Aldrich) [U. S. N. M.]. *Alberta*: ♀, Brooks, VI. 8.23 (Walter Carter); ♂, Cypress Hills, VI. 23.39 (W. S. McLeod); ♂, Medicine Hat, VIII. 8.39; ♀, Tofield, V. 22.23; ♂, Elk Island, VIII. 4.23 (E. H. Strickland) [Univ. Alberta]. 4 ♂, Cooking Lake, VIII. 16.36 (F. O. Morrison); 3 ♀, Lethbridge, VI. 6.23 (H. E. Gray); ♀, Waterton Lakes, VIII. 29.26 (N. Criddle); ♂, Banff, VIII. 8.22 (C. B. D. Garrett) [C. N. C.]. *British Columbia*: ♂, Oliver, VIII. 16.23 (C. B. D. Garrett); ♂, Vernon, IX. 21.27 (I. J. Ward); ♀, Crows Nest, VII. 26.26 (A. A. Denny) [C. N. C.]. ♂, South Fork Creek, VIII. 11.—; ♀, Kaslo, VIII. 3.— (R. P. Currie) [U. S. N. M.]. *California*: ♂, Orick,

VI. 22.39; 2 ♂, Junction, IX. 14. 39 (G. F. Knowlton) [Utah Agr. Col.]. ♀, Tule Lake Refuge, Siskiyou County, 4,150 ft. alt., VII. 1.37 (Bolinger-Jewett) [Ore. State Col.]. *Colorado*: ♂, Divide, VII. 19. 37 (M. & B. James); ♂, ♀, Cuchara, 8,000 ft. alt., VIII. 7. 40 (F. M. Snyder); ♀, Grand Lake, IX. - 26 (T. D. A. Cockerell); ♂, Ester Park, VIII. 24. 40 (G. F. Knowlton & W. P. Nye) [Utah Agr. Col.]. ♀, Tennessee Pass, VII. 25 17 (J. M. Aldrich) [U. S. N. M.]. *Idaho*: 5 ♀, Roswell, no date; ♂, Yale, Latah County, VII. 28. 27; ♀, Moscow, VI. 6. 12 (J. M. Aldrich) [U. S. N. M.]. ♂, Thousand Springs, IX. 19. 38 (G. F. Knowlton) [Utah Agr. Col.]. *Iowa*: ♂, Ames, VI. 5 27 (G. Hendrickson) [Iowa State Col.]. *Kansas*: ♂, ♀, Stafford County, IV. 29. 34 (C. W. Sabrosky) [Mich. State Col.]. *Manitoba*: ♂, Churchill, VIII. 2-9 37 (D. G. Denning); ♂, Churchill River, 20 mi. S. of Churchill, VIII. 5-6. 37 (R. H. Daggy) [F. M. Snyder]. *Minnesota*: ♀, Cook County, Cascade River near Lake Superior, VIII. 11. 29 (C. T. Schmidt) [F. M. Snyder]. *Missouri*: 2 ♀, Atherton, V. 15. 16 (J. M. Aldrich) [U. S. N. M.]. *Montana*: ♂, Summit Station, 5,200 ft. alt., VII. 25. - (J. M. Aldrich) [U. S. N. M.]. *New Jersey*: ♂, Riverton, VI. 26. 23 (H. C. Hallock). *New York*: ♂, Herkimer, VIII. 8. 21 (M. D. Leonard). ♂, Ithaca, V. 17 13. ♂, Canton, VII. 27. 31 (J. M. Aldrich) [U. S. N. M.]. *Oregon*: ♂, Lebanon, V. 27. 31 (J. Wilcox); ♀, Corvallis, VI. 3 31. 4 ♂, 3 ♀, Zumwalt, Wallowa County, VIII. 3 41; ♀, Whitney, Baker County, VIII. 6. 41 (M. & R. E. Rieder). *Quebec*: ♂, St. Anne de Bellevue, VIII. 26 18 (Macdonald College). *Saskatchewan*: 2 ♂, Regina, VII. 5 04 (T. N. Willing) [U. S. N. M.]. *South Dakota*: ♀, Brookings, VII. 16 19 (H. C. Severin) [Ohio State Museum]. 3 ♂, 3 ♀, Pringle, VII. 15 24; ♂, Hot Springs, VII. 13 24; ♀, Spearfish, VII. 30. 24; ♂, Custer, VII. 17 24; 2 ♀, Martin, VII. 7. 24 [South Dakota State Col.]. *Utah*: ♂, Utah Lake, east side, (Vasco M. Tanner); ♂, Spanish Fork, no date [Brigham Young Univ.], ♂, Hatch, IX. 14. 39; ♀, Corinne, III. 24. 34; ♀, Loa, IX. 11. 38; 2 ♀, Escalan Junction, IX. 11. 38; ♀, Fremont, IX. 8. 38; ♀, Gunnison, V. 28. 38 (G. F. Knowlton); ♂, Hooper, IX. 1. 37 (D. E. Hardy) [Utah Agr. Col.]. ♂, Soldier Summit, 7,454 ft. alt., VII. 6 - (J. M. Aldrich) [U. S. N. M.]. *Washington*: ♂, ♀, Lake Paha, IX. 20 20; ♂, Medical Lake, VII. 14 20; ♀, Ritzville, VI. 16 20; ♀, Stratford, IX. 4. 20 (R. C. Shannon). ♀, Bellingham, V. 31 17 (H. G. Dyar); ♀, Calfax, VII. 4. 12; ♂, 2 ♀, Friday Harbor, VII. 6 05 (J. M. Aldrich) [U. S. N. M.]. *Wisconsin*: ♀, Dane County, V. 27. 36; ♀, Columbia County, V. 10 36; ♂, ♀, Madison, V. 15. 36 (F. M. Snyder). *Wyoming*: ♂, Evanston, VII. 17. 40 (G. F. Knowlton and F. C. Harmston) [Utah Agr. Col.]. ♂, Black Sands Basin, Yellowstone National Park, no date, (Vasco M. Tanner) [Brigham Young Univ.]. *Yukon-Territory*: 2 ♂, White Horse, VI. 20. 19 (H. G. Dyar) [U. S. N. M.].

### *Hydrophoria proxima* Malloch

Figures 3, 31, 49

*Hydrophoria proxima* Malloch, Trans. Amer. Ent. Soc., 46: 171, 1920; Malloch, Can. Ent., 52: 254, 256, 1920; Johnson, Occ. Pap. Boston Soc. Nat. Hist., 7: 233, 1925; Frison, Bull. Ill. Nat. Hist. Surv., 16 (4): 200, 1927; Johnson, Insect. Faun. Biol. Surv. Mt. Desert Region, p. 210, 1927; Séguy, Gen. Insect., Fasc. 205, p. 134, 1937.

This species usually has a single fine hair on the upper margin of the hypopleura. In case this character may appear to be absent and to ensure the recognition of the species I have included it under both captions in the keys. In the male the eyes are separated by about the width of the third antennal segment, the processes are broad when viewed in profile and are devoid of any dense fringe of longish setulae on the inner margin, when viewed from below the apical region appears to taper and curl inward, the outer surface possesses one or two longish bristles. The fifth tergum has very weakly developed marginal bristles, the gonostyli (inferior forceps) are yellowish, slender and curved slightly at apex, clothed on the entire outer surface with long curling setulae.

In the female the anterior surface of the fore femur has one or more stoutish median setulae, the anal palpi have recurrent spinules; the parafrontals are not as broad nor as densely setulose as in *brunneifrons*. The female, like the male, has no weak bristle-like setae on the upper anterior border of the mesopleura adjacent to the anterior notopleural bristle, also in both sexes there are usually only two bristles on the posterodorsal surface of the hind tibia, and only one bristle on the posteroventral surface of the hind femur. The arista is long-haired, and the tibiae are black.

Ringdahl<sup>12</sup> has apparently described a closely allied species in *Acroptena separata* from northern Sweden, which may eventually be found to be identical with *proxima*.

*Material Examined*.—*Alaska*: 2 ♂, Savonoski, Naknek Lake, June 1919; 2 ♂, same locality, VIII.1.19 (J. S. Hine). *Maine*: ♂, Princeton, VII.12.09 [U. S. N. M.]. ♀, Bar Harbor, VII.11.23. *Ontario*: ♂, Waubamick, VI.15.—(H. S. Parish). *Washington*: ♀, Spokane, VIII.28.11 [U. S. N. M.].

### *Hydrophoria katmaiensis* Malloch

Figures 1, 18, 46

*Hydrophoria katmaiensis* Malloch, Trans. Amer. Ent. Soc., 46: 170, 1920; Malloch, Can. Ent., 52: 254, 1920; Séguy, Gen. Insect., Fasc., 205, p. 133, 1937.

*Acroptena kamtschatica* Ringdahl, Ark. Zool., 21 A (20): 8, 1930.

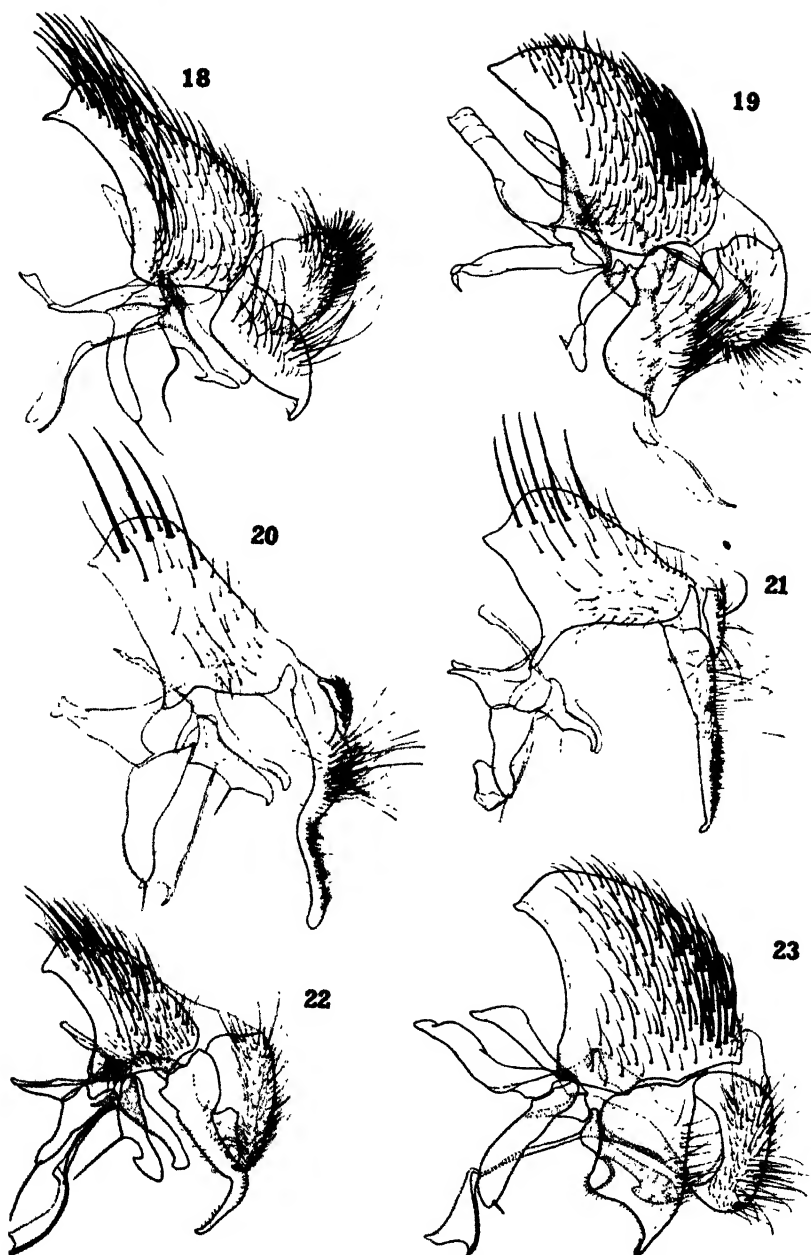
*Hydrophoria kamtschatica* Séguy, Gen. Insect., Fasc. 205, p. 133, 1937.

This species is closely allied to *brunneifrons*, from which it may be distinguished as cited in the keys. In the male of *katmaiensis* the apical region of the processes appears bent or curled inward, and the gonostyli (inferior forceps) are broad, curved slightly inward at the apex, and terminate in a short digitate process. The parafrontals of the male in profile are slightly narrower and the hairs of the arista in both sexes are scarcely as long as those of *brunneifrons*. In male specimens of *katmaiensis* the color of the mid and hind tibiae may range from yellowish

<sup>12</sup>Ringdahl, O. Neue skandinavische Dipteren, Ent. Tidskr., 41 (1): 30, 1920.

### EXPLANATION OF PLATE III

Lateral aspect of male copulatory appendages. Fig. 18. *Hydrophoria katmaiensis* Malloch. 19. *H. verticina* (Zetterstedt). 20. *H. ruralis* (Meigen). 21. *H. conica* (Wiedemann). 22. *H. brunneifrons* (Zetterstedt). 23. *H. frontala* (Zetterstedt).



to brownish, also the calyptrae and its hairs may be deeply infuscated or not so tinged.

**Material Examined.**—*Alaska*: 3 ♂, ♀, Savonoski, Naknek Lake, July 1919; ♂, Yakutat, no date, (J. S. Hine). *Manitoba*: ♀, Aweme, V.3.24 (N. Criddle) [C. N. C.]. 3 ♂, Churchill River, 20 mi. S. of Churchill, VIII.5-6.37 (D. G. Denning); 2 ♀, Churchill, VIII.2-9.37 (R. H. Daggy) [F. M. Snyder]. *Ontario*: ♂, Low Bush, Lake Abitibi, VII.27.25; ♀, same locality, VI.7.25 (N. K. Bigelow) [C. N. C.].

### *Hydrophoria brunneifrons* (Zetterstedt)

Figures 4, 22, 50

*Anthomyza brunneifrons* Zetterstedt, Insect. Lapp., p. 690, 1838; Zetterstedt, Dipt. Scand., 4: 1660, 1845.

*Anthomyia leate* Walker, List Dipt. Ins. Brit. Museum, 4: 931, 1849; Osten Sacken, Misc. Coll. Smithsn. Inst., 3: 169, 1878.

*Hylemyia brunneifrons* Stein, Ent. Nachr., 18 (20-21): 330, 1892; Lundbeck, Vidensk. Medd. Naturh. Foren. Kbhvn., 1: 313, 1898; Aldrich, Misc. Coll. Smithsn. Inst., 46 (1444): 552, 1905.

*Hydrophoria leate* Stein, Zeitschr. Hymn. Dipt., 1 (4): 213, 1901; Aldrich, Misc. Coll. Smithsn. Inst., 46 (1444): 551, 1905.

*Hydrophoria brunneifrons* Stein, Kat. Paläark. Dipt., 3: 684, 1907; Stein, Arch. f. Naturgesch., (1915) 81 A (10): 137, 1916; Henriksen and Lundbeck, Grönlands Landarthropoder, p. 639, 1917; Hockett, Can. Ent., 66: 140, 1934; Séguy, Gen. Insect., Fasc., 205, p. 132, 1937; Strickland, Can. Jour. Research, Sect. D, 16: 209, 1938.

*Acroptena brunneifrons* Stein, Arch. f. Naturgesch., (1913), 79 A (8): 31, 1914; Ringdahl, Ent. Tidskr., 39 (2): 187, 1918; Ringdahl, K. Svensk. Vetenskaps. Skrift. Naturskyddsärenden, Nr. 18, p. 18, 1931; Collin, Ann. Mag. Nat. Hist., ser. 10, 7: 84, 1931; Tiensuu, Acta Soc. Faun. Flor. Fenn., 58 (4): 31, 1935; Ringdahl, Opusc. Entom., 4 (3-4): 140, 1939.

*Hydrophoria occidentalis* Malloch, Trans. Amer. Ent. Soc., 46: 170, 1920; Malloch, Can. Ent., 52: 254, 1920; Séguy, Gen. Insect., Fasc. 205, p. 134, 1937.

The species *brunneifrons* and *kalmaiensis* possess many of the characters common to the *frontata* segregate, but they differ superficially from the latter in being paler and more heavily pruinescent. In males of both species the ninth tergum (anal sclerite) is clothed with diverse bristles, and in females the anal palpi possess recurrent spinules. In common with *divisa* the mid and hind tibiae of males tend to be brownish to yellowish and those of females yellowish in contrast to the blackish tibiae in closely related segregates. In the male of *brunneifrons* the processes are not flexed inward at apex, and the anal sclerite is not so deeply cleft by the membranous area as in *kalmaiensis*. The series of coarsely developed median setulae on the anterior surface of the fore femur may or may not be evident in *brunneifrons*, a character that seems to be constant in related species.

**Material Examined.**—*Alberta*: ♂, Banff, VI.21.22 (C. B. D. Garrett) [C. N. C.]. ♂, Wabamun, VI.27.36; ♀, Edmonton, V.1.24 (E. H. Strickland). ♀, Lethbridge, VI.6.23 (H. E. Gray). *Greenland*: ♀, Rødeg, VIII.17.92 (Deichmann) [U. S. N. M.]. *Idaho*: ♂, Paris, June 1926 (Vasco M. Tanner). *Nevada*: 2 ♂, 2 ♀, Wells, VI.20.27 (J. M. Aldrich); ♂, Wells, VII.12.11, holotype of *occidentalis* Mall. [U. S. N. M.]. *Ontario*: ♂, Waubamick, VI.—.15 (H. S. Parish) [A. L. Melander]. *Oregon*: 2 ♀, Crater Lake Park, near headquarters, 64-6600 ft. alt., VIII.29.30. ♀, Gold Beach, VII.12.25 (H. A. Scullen). ♂,

near Crane, VI. 28. 22 (W. J. Chamberlin). ♀, Hart Mt., Lake County, 7,000 ft. alt., VIII. 2. 32 (D. K. Frewing). 3 ♀, Breitenbush Lake, Marion County, VI. 23. 40. ♀, Rainier, VIII. 7. 36 (R. E. Rieder). ♀, Zumwalt, Wallowa County, VIII. 3. 41 (M. and R. E. Rieder). *Utah*: ♂, Clinton, V. 25. 39; ♀, Kaneshville, V. 15. 37; ♂, Huntsville, VI. 12. 37; ♂, ♀, Loa, IX. 8. 38; ♂, Bothwell, VI. 22. 38; ♀, Juab, meadow, V. 24. 38; ♂, Alton, IX. 14. 39; ♂, Benson, May 1939; ♂, Plain City, V. 10. 39; ♂, Woodruff, VII. 5. 35; ♀, Hooper, V. 8. 31 (all G. F. Knowlton). 3 ♂, ♀, Brigham, VI. 10. 38 (Knowlton, Hardy, Stains). ♀, Logan Canyon, VII. 26. 39 (Kye and Stains). ♀, Tremonton, X. 10. 34 (C. J. Sorenson). ♀, Smithfield, VII. 7. 37 (Smith and Harmston). ♂, Daniels, VI. 28. 40 (Knowlton and Harmston). 5 ♀, Far West, II. 7. 34 (W. L. Thomas). ♂, Paradise, 1934 (O. S. Lee). ♀, Promontory Point, VII. —. 11 (J. M. Aldrich) [U. S. N. M.]. *Washington*: ♀, Loon Lake, V. 16. 24; ♀, Orcas Island, above Mt. Lake, VIII. 16. 25 (A. L. Melander).

### *Hydrophoria wierzejskii* (Mik)

Figures 11, 32, 43

*Spilogaster wierzejskii* Mik, Verh. zool.-bot. Ges. Wien, 17: 420, 1867.

*Hydrophoria wierzejskii* Pandellé, Rev. ent. France, 18: 219, 1899; Stein, Kat. Paläark. Dipt., 3: 687, 1907; Ségué, Gen. Insect., Fasc. 205, p. 135, 1937; Strickland, Can. Jour. Research, Sect. D, 16: 209, 1938.

*Acroptena wierzejskii* Schnabl and Dziedzicki, Abh. K. Leop.-Carol. Deutsch. Akad. Naturforsch., 95 (2): 103, 1911; Stein, Arch. f. Naturgesch., (1913), 79 A (8): 31, 1914; Stein, Arch. f. Naturgesch., (1915), 81 A (10): 135, 1916; Ringdahl, Ent. Tidskr., 39 (2): 187, 1918; Ségué, Faune de France, 6: 147, 1923; Karl, Tierwelt Deutschlands, 13 (3): 120, 1928; Collin, Ent. Month. Mag., 66: 227, 1930.

*Hydrophoria elongata* Malloch, Trans. Amer. Ent. Soc., 46: 172, 1920; Malloch, Can. Ent., 52: 255, 256, 1920; Ségué, Gen. Insect., Fasc. 205, p. 133, 1937.

Males of this species may be readily recognized by the peculiar character of the fore tarsi, as indicated in the key, and by the abnormally slender mid and hind tarsi, the segments of which with the exception of the fifth are laterally compressed. The abdominal tuft is not conspicuous, the fifth abdominal sternum is polished and almost bare except for an inner marginal fringe, and the processes taper appreciably apicad. The female closely resembles that of *ambigua* Stein not Fallén.

In both sexes of *wierzejskii* there are weak bristles in the presutural acrostical series (as is also sometimes present in Stein's *ambigua*), the posteroventral surface of the hind femur is bare, that of the mid femur has only a few weak bristles which are scarcely longer than the apical posteroventral setae, the posterior notopleural bristle has one or more setulae at the base. Further, in the female the wings are yellowish basally, and there may be a weaker bristle developed basad of the medial anterodorsal bristle on mid tibia.

**Material Examined.**—*Alberta*: ♂, Banff, VIII. 18. 22 (C. B. D. Garrett); ♀, Lethbridge, VIII. 4. 24 (H. L. Seamans) [C. N. C.]. ♂, ♀, Cooking Lake, VII. 25. 37 (F. O. Morrison) [Univ. Alberta]. ♀, Bilby, VII. 28. 24 (Owen Bryant). *British Columbia*: ♂, Agassiz, VII. 29. 26 (H. H. Ross). ♀, Minnie Lake, VII. 25. 25 (N. Criddle). *Colorado*: ♀, Rogger, VIII. 31. 38; ♂, Walden, 8,500 ft. alt., IX. 1. 38 (C. L. Fluke)

[F. M. Snyder]. ♂, ♀, Grand Lake, IX.-.26 (T. D. A. Cockerell). ♀, Platte Canyon, Nr. Idlewild, VII.10.27 (J. M. Aldrich). *Idaho*: ♂, 2 ♀, St. Charles, VIII.10.39; ♀, Paris, VIII.10.39 (G. F. Knowlton, F. C. Harmston). *Manitoba*: 2 ♂, The Pas, VIII.11.37 (R. H. Daggy); ♀, Churchill River, 20 mi. S. of Churchill, VIII.5-6.37 (D. G. Denning) [F. M. Snyder]. ♂, ♀, Strathclair, VII.15.26; ♂, Darlingford, VIII.3.23; ♀, Lake Dauphine, VII.2.26 (N. Criddle) [C. N. C.]. *Michigan*: ♂, Detroit, IX.1.33 (Geo. Steyskal). *Missouri*: ♀, Atherton, V.15.16. *New York*: ♂, ♀, Canton, VII.27.31 (J. M. Aldrich) [U. S. N. M.]. *North Dakota*: ♂, ♀, Turtle Mts., near Bottineau, VI.21.18 [U. S. N. M.]. *Saskatchewan*: ♂, Dundern, VIII.19.- (N. Criddle); ♀, Birch Hills, VII.18.25 (K. M. King) [C. N. C.]. *South Dakota*: ♀, Fort Pierre, VIII.11.24; ♀, Custer, VII.17.24 [South Dakota State Col.]. *Utah*: ♂, Alton, IX.14.39; ♀, Lakota, VIII.5.39; ♂, Laketown, VIII.5.39 (G. F. Knowlton); ♀, Randolph, IX.21.38 (G. F. Knowlton, F. C. Harmston) [Utah Agr. Col.]. ♂, Geyser Pass, La Sal Mts., 10,000 ft. alt., no date, (Vasco M. Tanner) [Brigham Young Univ.]. *Washington*: 2 ♂, Medical Lake, VII.14.20 (R. C. Shannon). ♂, ♀, Pullman, no date, paratype of *elongata* Mall. [U. S. N. M.].

### *Hydrophoria borealis* Malloch

Figures 13, 33, 39

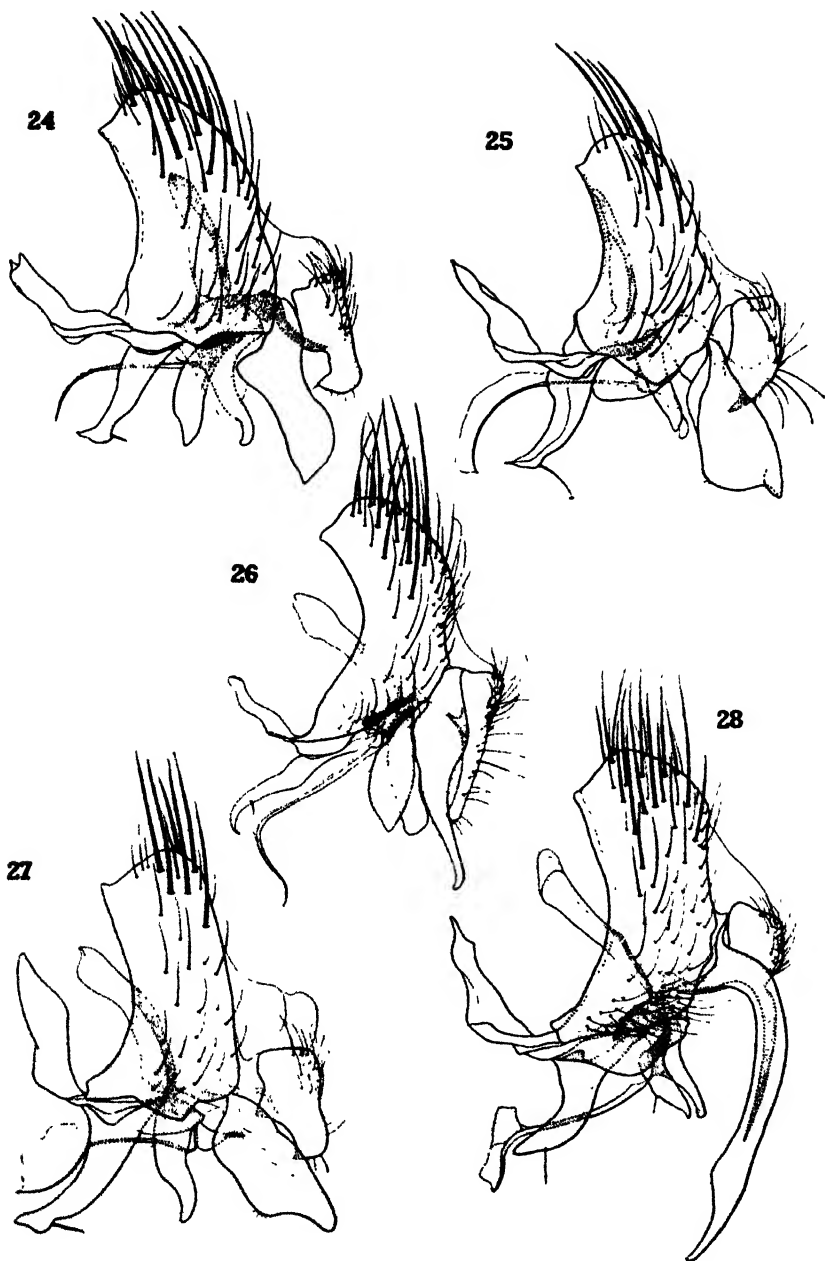
*Hydrophoria borealis* Malloch, Trans. Amer. Ent. Soc., 46: 172, 1920; Malloch, Can. Ent., 52: 255, 256, 1920; Séguy, Gen. Insect., Fasc. 205, p. 132, 1937.

The male of *borealis* has the abdomen tufted, and may be distinguished from closely related species possessing this character by the fact that the fourth abdominal tergum does not become conspicuously narrower toward the lateral margin (ventrad). This character is also true of the male of *wierzejskii*, which however differs in unique respects from other species belonging to the genus as already mentioned. In other ways *borealis* superficially resembles *flavohalterata*, the male of which has no true tuft in the accepted sense but does possess a number of closely placed bristles on the caudolateral area of the fourth abdominal tergum. In the female of *borealis* the tergal sclerites of the ovipositor are dull and opaque across the caudal region and the terminal plates possess ten to twelve coarse black spinules, whereas in *flavohalterata* the tergal sclerites are entirely polished and the terminal plates only possess four to six fine delicate spinules.

*Material Examined*.—*Alaska*: ♂, Anchorage, VI.11.21 (J. M. Aldrich) [U. S. N. M.]. 4 ♂, ♀, Katmai, June 1917; ♀, Savonoski, Naknek Lake, August 1919 (J. S. Hine). *Alberta*: ♂, Wabamun, VII.2.39 (E. H. Strickland) [Univ. Alberta]. ♂, Banff, VIII.18.22 (C. B. D. Garrett); ♀, Jasper, VII.25.23 (J. McDunnough) [C. N. C.]. *British Columbia*: ♂, ♀, Jordan River, VII.12.28 (W. Downes). ♂, Vancouver, V.20.-. *Idaho*: ♀, Priest Lake, (C. V. Piper) [U. S. N. M.].

### EXPLANATION OF PLATE IV

Lateral aspect of male copulatory appendages. Fig. 24. *Hydrophoria lucidiventris* (Zetterstedt). 25. *H. fasciculata* (Schnabl). 26. *H. ambigua* (Fallén). 27. *H. ignobilis* (Zetterstedt). 28. *H. laticornis* (Ringdahl).





*Minnesota*: ♀, Aitkin County, VII.4.37 (F. M. Snyder). *New Hampshire*: 2 ♀, White Mts., (Morrison) [U. S. N. M.]. *Ontario*: ♂, Abitibi Region, VI.6-8.15 (Cook); ♀, Low Bush, Lake Abitibi, VI.10.25 (N. K. Bigelow) [C. N. C.]. *Washington*: ♀, Mt. Rainier, above Longmire's, 5,000 ft. alt., VIII.3.05 (J. M. Aldrich) [U. S. N. M.]. ♂, Granite Falls, VII.25.25; ♀, Snoqualmie Pass, VI.29.24; ♀, Big Four Mts., VII.5.24; ♀, Orcas Island, above Mt. Lake, VIII.18.25 (all A. L. Melander). 2 ♂, ♀, Mt. Constitution, VII.17.09, paratypes [U. S. N. M.]. *Wisconsin*: ♂, ♀, Apostle Island, Ashland County, VII.4-11.07 [F. M. Snyder].

### ***Hydrophoria lucidiventris* (Zetterstedt)**

Figures 15, 24, 44

*Aricia lucidiventris* Zetterstedt, Dipt. Scand., 4: 1554, 1845.

*Aricia barbiventris* Zetterstedt, Dipt. Scand., 4: 1589, 1845.

*Hydrophoria barbiventris* Stein, Wien. Ent. Zeitg., 21: 30, 1902; Stein, Kat. Palaark. Dipt., 3: 684, 1907; Séguy, Gen. Insect., Fasc. 205, p. 132, 1937.

*Acroptena barbiventris* Stein, Arch. f. Naturgesch., (1913), 79 A (8): 32, 1914; Stein, Arch. f. Naturgesch., (1915), 81 A (10): 134, 1916; Ringdahl, Ent. Tidskr., 39 (2): 186, 1918; Ringdahl, Trömsö Museums Arshefter, (1926), 49 (3): 35, 1928; Ringdahl, K. Svensk. Vetenskaps. Skrift. Naturskyddsärenden, Nr. 18, p. 18, 1931.

*Acroptena lucidiventris* Ringdahl, Opusc. Entom., 4 (3-4): 149, 1939.

This species is listed by Séguy (1937) under the name *barbiventris* as occurring in North America. I have not been able to corroborate this record. A species that I consider tentatively as distinct from *lucidiventris* but which is evidently very similar was described by Malloch under the name *alaskensis*. My knowledge of *lucidiventris* is based on a large series of specimens collected in Swedish Lapland. In this material the male tuft arises closer to the basal region of the abdomen than in the case of *alaskensis*, in consequence of which the fifth tergum is proportionately longer along the lateral margin and the bristles composing the tuft, which reach to the end of abdomen, average longer than in *alaskensis*. Except for these rather arbitrary differences the males, in my opinion, agree in all other respects with males of *alaskensis*. I can find no specific differences between the respective females.

### ***Hydrophoria alaskensis* Malloch**

*Hydrophoria alaskensis* Malloch, Can. Ent., 52: 257, 1920; Malloch, Proc. Cal. Acad. Sci., ser. 4, 11 (14): 182, 1921; Malloch, North Amer. Faun. No. 46, U. S. Dept. Agr., pp. 192, 227, 1923; Séguy, Gen. Insect., Fasc. 205, p. 132, 1937.

I have tentatively considered *alaskensis* as apart from *lucidiventris* on the strength of male differences in the structure of the fifth abdominal tergum and in the relative position of the tuft on the abdomen. It is quite possible that a richer series of specimens showing a wider geographical distribution may indicate that these characters do not possess specific values.

*Material Examined*.—*Alaska*: ♂, St. George Id., Bering Sea, VI.8.14 (G. D. Hanna), holotype of *alaskensis*; 25 ♂, 28 ♀, same locality, VI 8-25.14 (G. D. Hanna), paratypes of *alaskensis* [U. S. N. M.]. ♀, St. Paul Island, VII.12.20 (G. D. Hanna). *Colorado*: ♂, Tennessee Pass, 10,240 ft. alt., VII.11.- (J. M. Aldrich). ♂, Summit Road, Ouray, 11,000 ft. alt., VII.13.19 [A. M. N. H.].

***Hydrophoria implicata* new name**

*Hydrophoria ambigua* Stein not Fallén, Berl. Ent. Zeitschr., (1897), 42 (3 4): 208, 1898; Smith, Ann. Rept. N. J. State Museum 1909, p. 791, 1910; Malloch, Can. Ent., 52: 255, 257, 1920; Huckett, Mem. 77, N. Y. (Cornell) Agr. Exp. Sta., (1923), p. 15, 1924; Hallock and Parker, Circ. 103, N. J. Dept. Agr., p. 16, 1926; Leonard, Mem. 101, N. Y. (Cornell) Agr. Exp. Sta., (1926), p. 837, 1928.

*Acroptena ambigua* Johnson, Occ. Pap. Boston Soc. Nat. Hist., 7: 233, 1925.

*Hydrophoria (Acroptena) ambigua* Johnson, Insect Faun. Biol. Surv. Mt. Desert Region, p. 210, 1927.

This widely distributed species has been recently recorded in North America as *ambigua* Fallén. This is undoubtedly a case of mistaken identity since it may be distinguished from Fallén's species by the tuft of bristles on the ventral surface of the male abdomen and by the sharply narrowing outline of the fourth tergum ventrad; in the female by the absence of bristles on the posteroventral surface of the hind femur. Females closely resemble *wierzejskii*, but differ in being slightly darker and having the veins on the basal region of the wings usually of a seal brown tinge, not yellowish. In addition there are no setulae at the base of the posterior notopleural bristle in either sex of *implicata*, whereas there are one or two inconspicuous setulae in this area in *wierzejskii*.

**Material Examined.** -- *British Columbia*: ♂, St. Marys, VII.12.26 (A. A. Dennys); ♀, Oliver, VIII.18.23 (C. B. D. Garrett) [C. N. C.]. ♂, Kaslo, VII.17. - (H. G. Dyar) [U. S. N. M.]. *District of Columbia*: ♂, Washington, July, (Coquillett) [U. S. N. M.]. *Idaho*: ♂, Priest Lake, VIII.1.16; ♀, Chatcolet, VIII.15. - (A. L. Melander) [U. S. N. M.]. *Illinois*: ♀, Cedar Lake, bog, VIII.6.06. *Maine*: ♀, Orrs Island, VII.28.07. ♀, Salisbury Cove, VII.15.23. 2 ♂, Pittston, VIII.3.30. ♂, Echo Lake, Mt. Desert, VI.17.21 (C. W. Johnson) [U. S. N. M.]. *Manitoba*: ♀, Churchill River, 20 mi S of Churchill, VIII.5.6.37 (R. H. Daggy) [F. M. Snyder]. *Massachusetts*: ♀, Chester, VIII.5.11. *Michigan*: 4 ♂, 2 ♀, Île Royale, VIII.3-7. - (C. W. Sabrosky); ♂, Cheboygan County, VII.7.40 (R. I. Sailer) [Mich. State Col.]. ♂, Cusino, VI.26-27.40 (T. F. Boyce). *Minnesota*: ♂, Aitkin County, VII.4.37 (F. M. Snyder). *Montana*: ♀, Lake McDonald, Glacier Park, VIII.14.16 (A. L. Melander) [U. S. N. M.]. *New Brunswick*: ♂, Shippigan, VII.14.31 (J. M. Aldrich); ♂, St. John, VII.24.01 (W. McIntosh); ♀, Oromocto, VII.9.13 (J. D. Tothill) [U. S. N. M.]. *New Hampshire*: ♂, White Mts., Dolly Copp, VII.13.31. ♂, White Mts., (Morrison); ♂, base of Mt. Washington, 2,600 ft. alt., (C. H. T. Townsend) [U. S. N. M.]. *New York*: 2 ♂, Canton, VII.27.31 (J. M. Aldrich) [U. S. N. M.]. ♂, North Fairhaven, VII.4.22 (R. C. Shannon); 2 ♂, 2 ♀, Ontario Beach, North Fairhaven, VIII.8.21 (L. S. West); ♂, Lake George, VII.25.29; 2 ♀, McLean bogs, McLean, VIII.18.28; 2 ♂, 3 ♀, Ringwood, near Ithaca, VI.26.20; ♂, Michigan Swamp, near Ithaca, VII.23.20; ♀, Freeville, VII.26.21; ♂, Renwick, Ithaca, VIII.8.20; 2 ♂, 2 ♀, Harmon, VII.5.26; ♂, Statten Island, VII.23.21; ♀, Montezuma Marsh, Cayuga County, VI.1.20; ♂, Watchogue, VII.14.21; ♀, Little Neck, Long Island, VI.25.21. *Nova Scotia*: 2 ♂, Truro, VII.8.13 (R. Matheson). *Ontario*: ♂, Lyn, VIII.10.26 (G. S. Walley) [C. N. C.]. *Pennsylvania*: ♀, Germantown, VI.4.05 [U. S.

N. M.]. *Quebec*: ♂, ♀, Gaspé Bay, VII. 17. 31 (J. M. Aldrich) [U. S. N. M.]. ♂, Knowlton, VII. 9. 27 (G. S. Walley); ♀, Hemmingford, VI. 26. 23 (C. H. Curran) [C. N. C.]. *Saskatchewan*: ♀, Maryfield, VIII. 31. 16 (N. Criddle). *Washington*: ♂, Puget, VIII. 30. 31 (J. Wilcox). 2 ♂, Coulee City, IX. 3. 20 (R. C. Shannon). *Wisconsin*: 2 ♂, Cranmoor, VIII. 30. 09 (C. W. Hooker) [U. S. N. M.]. ♂, Dane County, VI. 5. 38 (F. M. Snyder). ♂, Madison, IX. 29. 18 (C. L. Fluke).

### *Hydrophoria fasciculata* (Schnabl)

Figures 16, 25, 37

*Acroptena fasciculata* Schnabl, Mem. Acad. Imper. Sciences, Petrograd, ser. 8, 28 (7): 15, 1915.

*Acroptena incisurata* Ringdahl, Ent. Tidskr., 39 (2): 185, 1918; Ringdahl, Trömsö Museums Arsheft., (1928), 49 (3): 35, 1928; Ringdahl, Ark. Zool., 21 A (20): 4, 1930; Ringdahl, K. Svensk. Vetenskaps. Skrift, Naturskyddsärenden, Nr. 18, p. 18, 1931; Ringdahl, Ent. Tidskr., 53 (3): 174, 1931.

*Hydrophoria fasciculata* Ségué, Gen. Insect., Fasc. 205, p. 133, 1937.

The male of *fasciculata* resembles that of *implicata* in certain respects, but may be distinguished by the shorter hairs of the arista, shorter and less conspicuous tufts on the abdomen, a more pronounced fringe of setulae along the inner margin of the processes, and by being smaller. The female, unlike that of *implicata*, has weak bristles on the postero-ventral surface of the hind femur, and keys out close to *borealis* and *flavohalterata*, from both of which it may be distinguished by the slightly shorter-haired arista, the longest hairs being not much longer than the basal diameter of the arista. The female may further be distinguished from that of *borealis* in that the basal region of the wings is less distinctly tinged with fuscous, and from that of *flavohalterata* by the more shiny lustre of the dorsum of the thorax and abdomen.

*Material Examined*.—*Alberta*: ♀, Banff, V. 5. 22; ♂, ♀, same locality, VII. 25. 22 (C. B. D. Garrett) [C. N. C.].

### *Hydrophoria conica* (Wiedemann)

Figures 2, 21, 35

*Anthomyia conica* Wiedemann, Zool. Mag., 1 (1): 79, 1817; Meigen, Syst. Besch., 5: 97, 1826; Walker, List Dipt. Ins. Brit. Mus., 4: 917, 1849; Walker, Ins. Brit., 2: 134, 1853.

*Musca dubitata* Fallén, Muscides, p. 82, 1825.

*Musca conica* Fallén, Muscides, p. 83, 1825.

*Anthomyia distincta* Meigen, Syst. Besch., 5: 101, 1826.

*Anthomyia operosa* Meigen, Syst. Besch., 5: 102, 1826.

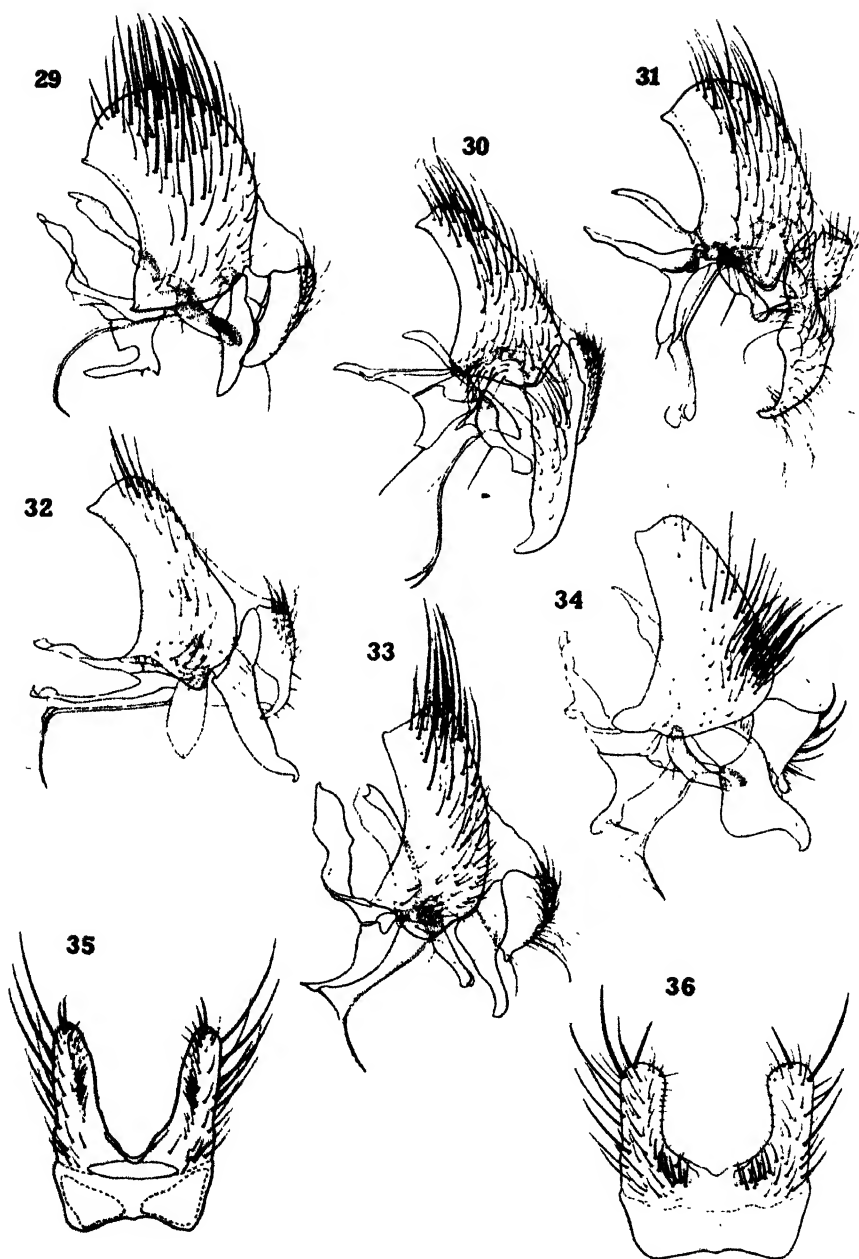
*Hydrophoria sagittariae* Rob.-Desv., Essai Myod., p. 505, 1830.

*Hydrophoria tibialis* Rob.-Desv., Essai Myod., p. 505, 1830.

*Hydrophoria conica* Macquart, Hist. Nat. Ins., 2: 298, 1835; Rondani, Dell. Soc. Ital. Sci. Natur., 9: 141, 1866; Rondani, Dipt. Ital., Prodr., 6: 172, 1877; Meade, Ent. Month. Mag., (1881-1882), 18: 102, 1881; Stein, Ent. Nachr., 14 (24): 375,

### EXPLANATION OF PLATE V

Lateral aspect of male copulatory appendages. Fig. 29. *Hydrophoria zetterstedti* (Ringdahl). 30. *H. divisa* (Meigen). 31. *H. proxima* Malloch. 32. *H. wierzejskii* (Mik). 33. *H. borealis* Malloch. 34. *H. seticanda* Malloch. Ventral aspect of fifth abdominal sternum in male. 35. *H. conica* (Wiedemann). 36. *H. ruralis* (Meigen).



1888; Strobl, Verh. zool.-bot. Ges. Wien, 43: 244, 1893; Meade, Descr. List Brit. Anth., 1: 31, 1897; Stein, Kat. Paläark. Dipt., 3: 684, 1907; Schnabl and Dziedzicki, Abh. K. Leop.-Carol. Deutsch. Akad. Naturforsch., 95 (2): 102, 1911; Stein, Arch. f. Naturgesch., (1913), 79 A (8): 31, 1914; Stein, Arch. f. Naturgesch., (1915), 81 A (10): 137, 1916; Séguéy, Faune de France, 6: 141, 1923; Ringdahl, Trömsö Museums Årshefter, (1926), 49 (3): 34, 1928; Karl, Tierwelt Deutschlands, 13 (3): 119, 1928; Ringdahl, Ark. Zool., 21 A (20): 4, 1930; Ringdahl, K. Svensk. Vetenskaps, Skrift. Naturskyddsårenden, Nr. 18, p. 17, 1931; Tiensuu, Acta Soc. Faun. Flor. Fenn., 58 (4): 31, 1935; Séguéy, Gen. Insect., Fasc. 205, p. 133, 1937.

*Hydrophoria caesia* Macquart, Hist. Nat. Ins., 2: 298, 1835.

*Hylemyia nigricans* Meigen, Syst. Besch., 7: 321, 1838.

*Anthomyia conica* Zetterstedt, Ins. Lapp., p. 689, 1938; Zetterstedt, Dipt. Scand., 4: 1652, 1845; Siebke, Enum. Insect. Norveg., p. 117, 1877.

*Anthomyia monticola* Zetterstedt, Dipt. Scand., 8: 3306, 1849; Siebke, Enum. Insect. Norveg., p. 118, 1877.

*Anthomyia inquirenda* Zetterstedt, Dipt. Scand., 8: 3307, 1849.

*Anthomyia subtracta* Walker, Ins. Brit., 2: 135, 1853.

*Hylemyia conica* Schiner, Faun. Austr., 1: 631, 1862; Neuhaus, Dipt. March., p. 224, 1886; Pandellé, Rev. Ent. France, 18: 216, 1899.

*Hydrophoria conica alpicola* Strobl, Mitt. Verh. Steiermark., (1897), p. 244, 1898.

This well known European species has hitherto remained unrecorded from North America. It is typical of a small group of species which lack the three characteristic black vittae along the thorax; all the species are without a medial anteroventral bristle on the mid tibia, the hairs of the arista are pectinate, and in the female the caudal pair of ocellar bristles is widely divergent and directed outwards. *Conica* has a long prealar bristle, and is larger than the related forms *ruralis* and *galeata*.

*Material Examined*.—*Connecticut*: 4 ♂, 2 ♀, Litchfield County, V. 30.39 (F. M. Snyder). ♂, Redding, V. 30.31 (A. L. Melander). *New York*: ♀, Riverhead, Long Island, VI. 26.27; ♀, Orient, Long Island, VI. 6.36; ♀, same locality, VI. 20.36 (H. C. Hockett). 3 ♂, Patterson, V. 19.35 (H. Dietrich) [C. U.].

### *Hydrophoria galeata* Malloch

*Hydrophoria galeata* Malloch, Ohio Jour. Sci., 20 (7): 270, 1920; Malloch, Can. Ent., 52: 254, 1920; Séguéy, Gen. Insect., Fasc. 205, p. 133, 1937.

This species is closely related to *ruralis*, and both belong to the same segregate with *conica*. The male of *galeata* may be distinguished from that of *ruralis* by the wider parafacials, the presence of a bristle on the posterior surface of the hind tibia, and by the entirely blackish abdomen. In the female of *galeata* the marginal bristles of tergum 5 are weaker, and the abdominal vitta on the basal two segments is less widely developed than in *ruralis*. The tibiae may be blackish, brownish or yellowish in color.

*Material Examined*.—*Alaska*: ♂, Savonoski, Naknek Lake, June 1919 (J. S. Hine). *Alberta*: ♂, Gull Lake, VI. 19.29 (E. H. Strickland) [Univ. Alberta]. ♂, Banff, VI. 29.17; ♀, Chin, VI. 7.23 (H. L. Seamans). *British Columbia*: ♀, Oliver, V. 9.23 (C. B. D. Garrett) [C. N. C.]. *Colorado*: 5 ♀, no data, (Coquillett) [U. S. N. M.]. ♀, Cuchara, 10,000 ft. alt., VIII. 7.40 (F. M. Snyder). *South Dakota*: ♂, Mobridge, VIII. 13.24. ♀, Custer, VII. 15.24. *Utah*: ♂, Ogden, VI. 26.37 (D. E. Hardy).

**Hydrophoria ruralis** (Meigen)

Figures 8, 20, 36

- Anthomyia ruralis* Meigen, Syst. Besch., 5: 101, 1826; Walker, List Dipt. Ins. Brit. Mus., 4: 919, 1849.
- Hydrophoria testacea* Rob.-Desv., Essai Myod., 506, 1830; Macquart, Hist. Nat. Ins., 2: 298, 1835.
- Hydrophoria maculata* Macquart, Hist. Nat. Ins., 2: 299, 1835.
- Hydrophoria maculata* Meigen, Syst. Besch., 7: 320, 1838.
- Hydrophoria anthomyia* Rond., Dell. Soc. Ital. Sci. Natur., 9: 141, 1866; Rondani, Dipt. Ital., Prodr., 6: 171, 1877; Stein, Ent. Nachr., 14 (24): 375, 1888; Meade, Entom. Month. Mag., 18: 103, 1881; Strobl, Verh. zool.-bot. Ges. Wien, 43: 243, 1893; Meade, Descr. List Brit. Anth., 1: 31, 1897.
- Hylemyia ruralis* Neuhaus, Dipt. March., p. 224, 1886.
- Hylemyia plumosior* Pandellé, Rev. Ent. France, 18: 216, 1899.
- Hydrophoria ruralis* Stein, Kat. Palaark. Dipt., 3: 687, 1907; Stein, Arch. f. Naturgesch., 77 A (1): 149, 1911; Schnabl and Dziedzicki, Abh. K. Leop.-Carol. Deutsch. Akad. Naturforsch., 95 (2): 102, 1911; Stein, Arch. f. Naturgesch., (1913), 79 A (8): 31, 1914; Stein, Arch. f. Naturgesch., (1915), 81 A (10): 137, 1916; Stein, Arch. f. Naturgesch., (1918), 84 A (9): 74, 1920; Séguy, Faune de France, 6: 142, 1923; Huckett, Mem. 77, N. Y. (Cornell) Agr. Exp. Sta., (1923), p. 16, 1924; Karl, Tierwelt Deutschlands, 13 (3): 119, 1928; Leonard, Mem. 101, N. Y. (Cornell) Agr. Exp. Sta., (1926), p. 837, 1928; Séguy, Gen. Insect. Fasc. 205, p. 134, 1937; Strickland, Can. Jour. Research, Sect. D, 16: 209, 1938.
- Hydrophoria subpellucida* Malloch, Trans. Amer. Ent. Soc., 44: 296, 1918; Frison, Bull. Ill. Nat. Hist. Surv., 16 (4): 200, 1927; Séguy, Gen. Insect, Fasc. 205, p. 134, 1937.
- Hydrophoria subpellucens* Malloch, Can. Ent., 52: 254, 256, 1920; Strickland, Can. Jour. Research, Sect. D, 16: 209, 1938.

In typical forms *ruralis* has the abdomen tinged with yellowish on the basal half, and in the male the fourth and fifth terga possess a pair of brownish marks on the cephalic region in addition to a dorsocentral vitta. The distal half of the proboscis is slightly stouter than in *galeata*, and in the female the marginal bristles of tergum 5 are more strongly developed and the dorsocentral vitta on the two basal abdominal segments considerably wider than in *galeata*. The female specimens from Banff do not exhibit the yellowish color on abdomen, but otherwise they conform closely to the characters possessed by *ruralis*. Malloch (1920) recognized the similarity between *subpellucida* and *ruralis*, but preferred to treat them as distinct species pending further study. The males of North American specimens differ from those of Europe that I have seen in having the preapical posterodorsal bristle and one or two adjacent setulae on the hind tibia fine and longish, and in both sexes the number of anterodorsal bristles is usually greater. Otherwise, in my opinion, there seems to be no significant differences between the two forms to warrant their recognition as distinct species.

**Material Examined.**—*Alberta*: 3 ♀, Banff, IX.12.36 (T. D. A. Cockerell) [Univ. Alberta]. *Arizona*: 9 ♂, 2 ♀, Cave Creek Canyon, Chiricahua Mts., VII.4-8.40 (D. G. Hall). *New Mexico*: ♂, Alamo-gordo, IV.30.02, type of *subpellucida* Mall. [A. N. S. P.].<sup>13</sup> *New York*: ♂, Ithaca, no date, (O. A. Johannsen) [C. U.]. *North Carolina*: ♀, no date [U. S. N. M.]. *Pennsylvania*: ♂, Westmor County, July [Carnegie Museum]. *Ohio*: ♂, Vinton, VI.5-12.00 (J. S. Hine). *South Dakota*: ♀, Pierre, no date (J. M. Aldrich) [U. S. N. M.]. *West Virginia*: ♂, Cheat River, June [Carnegie Museum].

<sup>13</sup>Academy of Natural Sciences, Philadelphia.

**Hydrophoria zetterstedti** (Ringdahl)

Figures 14, 29, 38

*Acroptena zetterstedti* Ringdahl, Ent. Tidskr., 39 (2): 185, 1918; Ringdahl, Tromsø Museums Arshefter, (1926), 49 (3): 35, 1928; Ringdahl, Ark. Zool., 21 A (20): 4, 1930; Ringdahl, K. Svensk. Vetenskaps. Skrift. Naturskyddsårenden, Nr. 18, p. 18, 1931; Tiensuu, Acta Soc. Faun. Flor. Fenn., 58 (4): 32, 1935; Séguy, Gen. Insect., Fasc. 205, p. 135, 1937; Strickland, Can. Jour. Research, Sect. D, 16: 209, 1938.

This species may be readily distinguished from related forms by the possession of the following combination of characters: a long prealar bristle, minutely-haired arista, two medial anterodorsal bristles on mid tibia, yellowish tinge to basal region of wings and to calyptres. The hypopleura is not haired on the upper margin nor is the abdomen tufted. I have seen specimens of *laticornis* that approach *zetterstedti* on the basis of such characters, but in the male of *laticornis* the processes have a few longish bristles on the outer surface, and in the female the anal palpi are dull and opaque, whereas in *zetterstedti* the processes are finely and weakly setose and the anal palpi are lustrous and shiny.

*Material Examined*.—*Alaska*: ♀, Healy, V. 26.21. ♂, ♀, Yakutat, VI 21.99 (T. Kincaid) [U. S. N. M.]. *Alberta*: ♂, Gull Lake, VI 4.39; ♂, Wabamun, VII.2.39; ♀, Edmonton, VI 7.35 (E. H. Strickland); ♂, Cooking Lake, VI.13.37 (F. O. Morrison) [Univ. Alberta]. ♀, Waterton, VII.2.24 (H. L. Seamans); 2 ♂, Banff, V 31.22 (C. B. D. Garrett) [C. N. C.]. *Montana*: ♀, Glacier Park Station, 4,800 ft. alt., VII.24 – (J. M. Aldrich) [U. S. N. M.]. *Ontario*: ♀, Low Bush, Lake Abitibi, VI 24.25 (N. K. Bigelow) [C. N. C.].

**Hydrophoria seticauda** Malloch

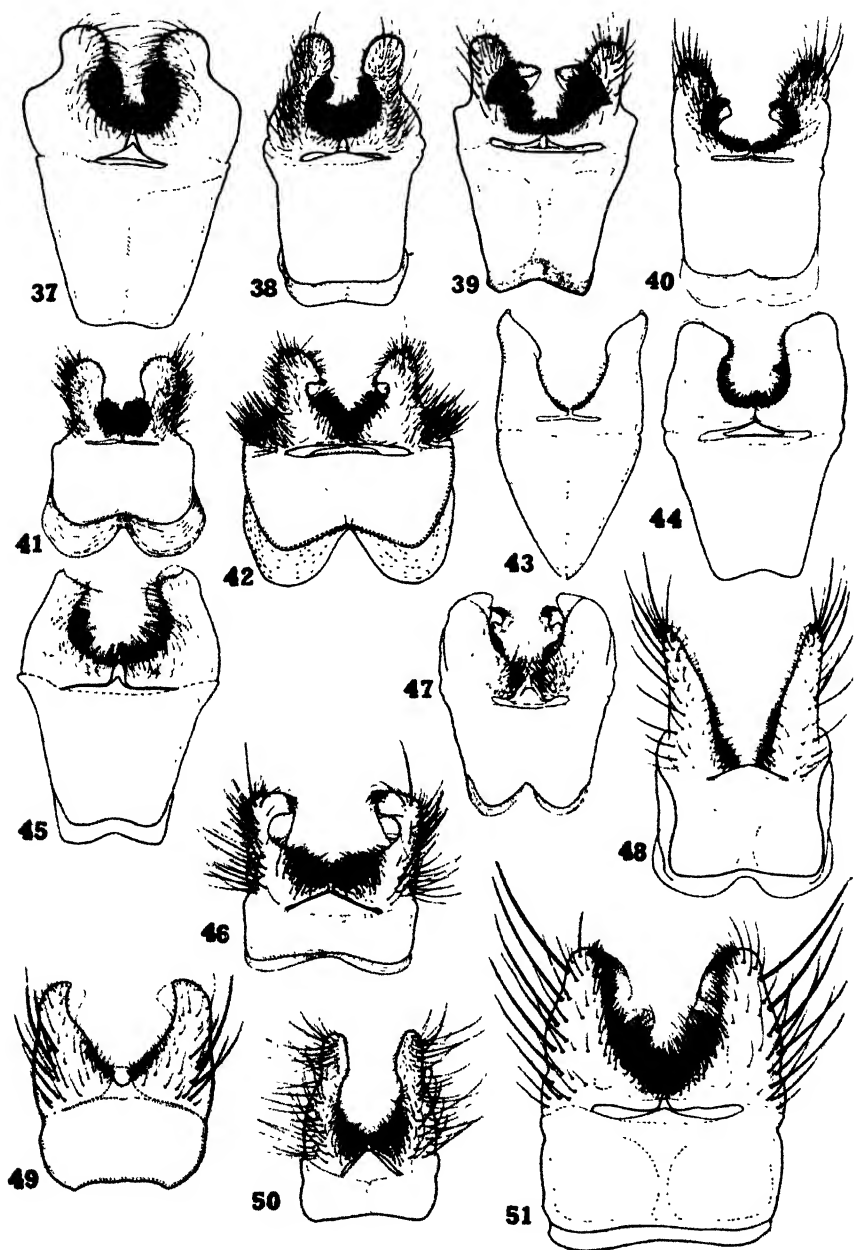
Figures 6, 34, 47

*Hydrophoria seticauda* Malloch, Proc. Cal. Acad. Sci., ser. 4, 9 (11): 306, 1919; Malloch, Can. Ent., 52: 254, 256, 1920; Séguy, Gen. Insect., Fasc. 205, p. 134, 1937.

The male of *seticauda* may be readily recognized owing to the flattish appressed character of the ninth tergum when viewed from behind, which serves to give the abdomen an abrupt truncated appearance.<sup>4</sup> The anal sclerite is clothed with weak bristles which become denser caudad (ventrad), and which curl inward at tip. The medial bristles of the marginal series on tergum 5 are much further from the caudal margin than those situated laterad, the integument along the caudal border being extensively membranous. The hind tibiae usually possess one or two short bristles on the proximal half of the posterior or posteroventral surface. The female, like the male, has one or more pairs of weak pre-

## EXPLANATION OF PLATE VI

Ventral aspect of fifth abdominal sternum in male. Fig. 37. *Hydrophoria fasciculata* (Schnabl). 38. *H. zetterstedti* (Ringdahl). 39. *H. borealis* Malloch. 40. *H. ambigua* (Fallén). 41. *H. frontata* (Zetterstedt). 42. *H. verticina* (Zetterstedt). 43. *H. wierzejskii* (Mik). 44. *H. lucidiventris* (Zetterstedt). 45. *H. ignobilis* (Zetterstedt). 46. *H. katmaiensis* Malloch. 47. *H. seticauda* Malloch. 48. *H. divisa* (Meigen). 49. *H. proxima* Malloch. 50. *H. brunneifrons* (Zetterstedt). 51. *H. laticornis* (Ringdahl).





sutural acrostical bristles, the arisal hairs are about as long as half the width of the third antennal segment, the terminal sclerites of the ovipositor are armed with about twelve coarse blackish spinules. From females of *ambigua* (Fallén) the species may be distinguished by the absence of setulae at the base of the posterior notopleural bristle and by the blackish and more shiny abdomen, resembling the femora in this respect.

*Material Examined.*—*Alaska*: ♂, Port Althorp, VI.5.21 (J. M. Aldrich); ♂, Mablakahbla, VI.4.99 (T. Kincaid) [U. S. N. M.]. *British Columbia*: ♂, Vancouver, VI.9.06 (R. S. Sherman). ♂, Agassiz, V.27.27 (H. H. Ross) [C. N. C.]. *California*: ♂, Mill Creek Canyon, San Bernardino Mts., VI.9.24 (J. M. Aldrich) [U. S. N. M.]. *Idaho*: ♂, ♀, Mt. Moscow, VI.4.10. 2 ♀, Mts., Moscow, VI.25.20 (R. C. Shannon). ♂, St. Regis Pass, VII.1.23 (A. L. Melander). ♀, Moores Lake, VII.10.07 (J. M. Aldrich) [U. S. N. M.]. *Nevada*: ♂, Ormsby County, VII.6.— (Baker) [U. S. N. M.]. *Oregon*: ♂, Eddyville, III.30.30 (J. Wilcox). 3 ♂, Marshfield, VI.28.— (J. M. Aldrich) [U. S. N. M.]. ♂, Hood River, no date (Childs). ♀, Corvallis, V.8.29 (John Wieting). ♀, Melhorn's Mill, near Halfway, Baker County, VII.4.22 (W. J. Chamberlain). *Utah*: ♂, Salt Lake, VI.24.22, 6–7,000 ft. alt. (A. L. Lovett). ♀, Strawberry Valley, VI.27.40 (G. F. Knowlton, F. C. Harmston). ♂, Logan Canyon, VII.25.37 (G. F. Knowlton). *Washington*: ♀, Ilwaco, VII.12.18 (A. Spuler). ♀, Fairfax, VII.12.30. ♂, Valleyford, V.17.24; ♂, Hudson Creek, VI.29.24; 2 ♀, Granite Falls, VII.25.25; 2 ♀, Snoqualmie Pass, VI.29.24 (A. L. Melander). 2 ♀, Friday Harbor, VII.6.05; ♀, Longmire's Springs, Mt. Rainier, VIII.2.05 (J. M. Aldrich) [U. S. N. M.].

### *Hydrophoria uniformis* Malloch

*Hydrophoria uniformis* Malloch, Trans. Amer. Ent. Soc., 44: 297, 1918; Malloch, Can. Ent., 52: 255, 256, 1920; Hockett, Mem. 77, N. Y. (Cornell) Agr. Exp. Sta., (1923), p. 16, 1924; Johnson, Occ. Pap. Boston Soc. Nat. Hist., 7: 233, 1925; Hallock and Parker, Circ. 103, N. J. Dept. Agr., p. 16, 1926; Frison, Bull. Ill. Nat. Hist. Surv., 16 (4): 201, 1927; Johnson, Insect Faun. Biol. Surv. Mt. Desert Region, p. 210, 1927; Leonard, Mem. 101, N. Y. (Cornell) Agr. Exp. Sta., (1926), p. 837, 1928; Ségué, Gen. Insect., Fasc. 205, p. 134, 1937; Brimley, Insect. North Carolina, p. 376, 1938.

The male of *uniformis* may be distinguished from related forms by the conspicuous series of curling bristles and slender setulae arising respectively along the entire length of the outer and inner surfaces of the processes. In both sexes the mid tibia lacks the normal preapical mid-dorsal bristle, and the parafacials become much narrower ventrad. The dorsum of the abdomen is marked transversely by dark marginal incisures, being most conspicuous in the male. The species may or may not possess weak bristle-like setae among the presutural acrosticals and on the upper anterior region of the mesopleura adjacent to the anterior notopleural bristle.

*Material Examined.*—*Connecticut*: ♀, Branford, VII.28.05 (H. L. Viereck). *Georgia*: 10 ♂, Clayton, IV.15–22.40 (H. C. Hockett). *Idaho*: ♂, Mt. Moscow, VII.12.24; ♂, ♀, Moscow, VII.17.24; ♀, Elk River, VII.15.10 (J. M. Aldrich) [U. S. N. M.]. *Illinois*: ♂,

Urbana, IV.6.09; ♂, same locality, IV.5.09, paratypes [U. S. N. M.]. *Maryland*: 2 ♂, Beltsville, IV.30.16; 5 ♂, same locality, VII.4-30.16 (W. L. McAtee), paratypes [U. S. N. M.]. ♂, Lakeland, VII.5.09 (Fredk. Knab) [U. S. N. M.]. *Massachusetts*: ♂, Petersham, VI.30.31 (A. L. Melander). *New Jersey*: ♀, Ridgewood, VII.5.11 (M. D. Leonard). *New York*: ♀, Oswego, VII.17.96 [U. S. N. M.]. ♂, McLean Bogs, Tompkins County, VI.30.21; 8 ♂, Ringwood, near Ithaca, VI.26.20; ♂, Slaterville, VIII.16.28; 8 ♂, Buttermilk, near Ithaca, VII.10.20; ♂, Michigan Swamp, Tompkins County, VII.23.20; ♀, Statten Island, VII.23.21; ♀, Roslyn, Long Island, VIII.25.21 (H. C. Huckett). ♂, Ithaca, VI.22.36 [C. U.]. *Ohio*: ♂, Cranberry Harvest, Buckeye Lake, Licking County, VI.13.31 (M. D. Neiswander) [Ohio State Museum]. ♂, Sugar Grove, VI.10.28 [U. S. N. M.]. *Ontario*: ♀, Low Bush, Lake Abitibi, VI.10.25 (N. K. Bigelow). *Pennsylvania*: ♂, ♀, Allegheny County, June [Carnegie Museum]. *Quebec*: ♀, Rigaud, VII.20.20. *Vermont*: ♀, St. Albans, VI.19.13 (C. W. Johnson). *Virginia*: 2 ♂, Dead Run, Fairfax County, V.27.25 (R. C. Shannon); ♂, Falls Church, VI.21.14; 2 ♂, Four Mile Run, VII.13.12 (Fredk. Knab); ♂, Black Pond, VIII.27.19; 4 ♂, Great Falls, VI.25.20 (C. T. Greene); ♂, Roslyn, III.24.- (Townsend); 2 ♂, Occoquan, V.27.23 (J. M. Aldrich) [U. S. N. M.]. *West Virginia*: 3 ♂, Cheat Mts., June [Carnegie Museum]. *Wisconsin*: 4 ♂, Dane County, V.22.36 (F. M. Snyder).

### *Hydrophoria ignobilis* (Zetterstedt)

Figures 12, 27, 45

*Aricia ignobilis* Zetterstedt, Dipt. Scand., 4: 1448, 1845.

*Hydrophoria ignobilis* Stein, Wien. Ent. Zeitg., 21: 33, 1902; Stein, Kat. Paläarkt. Dipt., 3: 686, 1907.

*Acroptena ignobilis* Stein, Arch. f. Naturgesch., (1913), 79 A (8): 32, 1914; Stein, Arch. f. Naturgesch., (1915), 81 A (10): 134, 1916; Ringdahl, Ent. Tidskr., 39 (2): 188, 1918; Stein, Arch. f. Naturgesch., (1918), 84 A (9): 74, 1920; Ringdahl, Trömsö Museums Arshefter, (1926), 49 (3): 35, 1928; Ringdahl, Ark. Zool., 21 A (20): 4, 1930; Ringdahl, K. Svensk. Vetenskaps. Skrift. Naturskyddsarenen, Nr. 18, p. 18, 1931; Tiensuu, Acta Soc. Faun. Flor. Fenn., 58 (4): 32, 1935; Séguy, Gen. Insect., Fasc. 205, p. 133, 1937; Ringdahl, Opusc. entom., 4 (3-4): 149, 1939.

This small species superficially resembles *flavohalterata* and *borealis*. In the male of *borealis* however the abdomen is tufted on tergum 4, whereas in *flavohalterata* and *ignobilis* the caudoventral region of tergum 4 bears a loose series of longish appressed bristles, which is not to be confused with the characteristic "tuft" on many species in the genus. In both sexes of *ignobilis* the hind femur is usually bare on the posteroventral surface, or occasionally may possess a single bristle at the middle, whereas in *flavohalterata* the bristles occur in series on the proximal third of the posteroventral surface. Further, in the male of *ignobilis* the bristles on the posteroventral surface of the mid femur are uniformly short, scarcely as long as the width of the femur where situated. The female of *ignobilis* may be separated from its closest relatives by the bare posteroventral surface on the hind femur. The species runs out with *seticauda* in the female key, being distinguished from the latter by the absence of weak bristle-like setae among the

presutural acrosticals, and by the coarser spinular development of setulae across the cephalic border of the mesonotum.

**Material Examined.**—*Alaska*: 2 ♂, Fairbanks, VII.3.21; ♀, Camp 334, Alaska Eng. Comm., VII.9.21 (J. M. Aldrich). *Alberta*: ♂, 2 ♀, Banff, VIII.18.22; ♂, same locality, V.25.22 (C. B. D. Garrett) [C. N. C.].

### *Hydrophoria ambigua* (Fallén)

Figures 10, 26, 40

*Musca ambigua* Fallén, Muscides, p. 56, 1823.

*Anthomyia ambigua* Meigen, Syst. Besch., 5: 192, 1826; Walker, List Dipt. Ins. Brit. Mus., 4: 925, 1849.

*Aricia ambigua* Zetterstedt p. p., Dipt. Scand., 4: 1415, 1845; Zetterstedt, Dipt. Scand., 12: 4719, 1855; Zetterstedt, Dipt. Scand., 14: 6204, 1860; Siebke, Enum. Insect. Norveg., 4: 104, 1877.

*Spilogaster ambigua* Schiner, Faun. Austr., 1: 612, 1862.

*Hydrophoria ambigua* Rondani, Dell. Soc. Ital. Sci. Natur., 9: 140, 1866; Rondani, Dipt. Ital., Prodr., 6: 175, 1877; Meade, Ent. Month. Mag., (1881–1882), 18: 102, 1881; Stein, Ent. Nachr., 14 (24): 375, 1888; Strobl, Verh. zool.-bot. Ges. Wien, 43: 242, 1893; Meade, Descr. List Brit. Anth., 1: 30, 1897; Pandellé, Rev. Ent. France, 19: 221, 1900; Coquillett, Proc. Wash. Acad. Sci., 2: 447, 1900; Aldrich, Misc. Coll. Smithsn. Inst., 46 (1444): 551, 1905; Stein, Kat. Paläark. Dipt. 3: 684, 1907; Séguéy, Gen. Insect., Fasc. 205, p. 132, 1937.

*Acroptena ambigua* Schnabl and Dziedzicki, Abh. K. Leop.-Carol. Deutsch. Akad. Naturforsch., 95 (2): 103, 1911; Stein, Arch. f. Naturgesch., (1915), 81 A (10): 133, 1916; Ringdahl, Ent. Tidskr., 39 (2): 187, 1918; Stein, Arch. f. Naturgesch., (1918), 84 A (9): 74, 1920; Séguéy, Faune de France, 6: 146, 1923; Karf, Tierwelt Deutschlands, 13 (3): 120, 1928; Ringdahl, Trömsö Museums Arshefter, (1926), 49 (3): 35, 1928; Ringdahl, Ark. Zool., 21 A (20): 4, 1930; Collin, Ent. Month. Mag., 66: 228, 1930; Ringdahl, K. Svensk. Vetenskaps. Skrift. Naturskyddsärenden, Nr. 18, p. 18, 1931; Tiensuu, Acta Soc. Faun. Flor. Fenn., 58 (4): 32, 1935.

*Hydrophoria coloradensis* Malloch, Trans. Amer. Ent. Soc., 46: 172, 1920; Séguéy, Gen. Insect., Fasc. 205, p. 132, 1937.

The male of *ambigua* has no true tuft as in *implicata*, with which species it has been confused, but does possess a number of fine longish bristles along the lateral borders of abdominal terga 4 and 5. The processes have an outer series of weak bristles and an inner series of fine setulae from base to apex; the basal plate of the fifth sternum is invariably conspicuous, being black and polished. The abdomen is cinereous gray with the dorsocentral vitta becoming perceptibly narrower caudad with each successive segment. The female of *ambigua* is more densely cinereous, the terga of the ovipositor are dull and opaque, not polished and lustrous as in *flavohalterata*, and in some specimens there is a pair of weak bristle-like setae among the presutural acrosticals.

**Material Examined.**—*Alaska*: ♀, Fairbanks, VII.2.21 (J. M. Aldrich) [U. S. N. M.]. *Colorado*: ♂, Pingree Park, no date, (Vasco M. Tanner). ♂, Platte Canyon, near Idlewild, VII.10.27; ♂, Tennessee Pass, VII.17.17 (J. M. Aldrich), holotype of *coloradensis* Mall. [U. S. N. M.]. ♀, Long Lake, Boulder County, August, (T. D. A. Cockerell). ♀, Cameron Pass, VIII.19–22.40 (Sabrosky). ♂, Gould, VIII.18.40 (G. F. Knowlton). *Utah*: ♂, Geyser Pass, La Sal Mts., 9,500 ft. alt., no date (Vasco M. Tanner). *Washington*: ♀, Pullman, V.22.23 (A. L. Melander). ♀, Ilwaco, VI.6.18 (A. Spuler).

***Hydrophoria flavohalterata* Malloch**

*Hydrophoria flavohalterata* Malloch, Trans. Amer. Ent. Soc., 46: 171, 1920; Malloch, Can. Ent., 52: 255, 256, 1920; Ségué, Gen. Insect., Fasc. 205, p. 133, 1937.

The male of *flavohalterata* structurally resembles that of *ambigua* (Fallén), differing in that the dorsocentral vitta of the abdomen is nearly uniformly broad on terga 3, 4 and 5, and the dark anterior incisures are more in evidence. In both sexes the presutural acrosticals are all setulose, and in the female the tergal sclerites of the ovipositor are entirely polished and shining, whereas in *ambigua*, *borealis*, *fasciculata* and *ignobilis* the terga are at least partly dull and opaque. This species was erroneously included in the New York list from specimens which have since been found to be representative of *implicata*. The species *flavohalterata* comes closest to the European form *tristis* Ringdahl,<sup>14</sup> with which it may eventually be found to be identical.

**Material Examined.**—*Idaho*: ♂, Moscow, VI. 5.12; ♀, same locality, VI. 6.12 (J. M. Aldrich), holotype and allotype [U. S. N. M.]. ♂, Newman, Lake, V. 16.25 (A. L. Melander). 2 ♂, Lawyers Canyon, VI. 16.09, paratypes [U. S. N. M.]. *Utah*: ♀, Card Canyon, Logan Canyon, VII. 24.38 (W. P. Nye). *Washington*: ♂, Kampiac Butte, VI. 1.12, paratype; ♂, Loon Lake, V. 16.24 (A. L. Melander). ♀, Pullman, V. 12.12; ♀, Uniontown, VI. 26.32 (J. M. Aldrich) [U. S. N. M.]. 2 ♀, Ewan, VI. 13.20 (R. C. Shannon).

***Hydrophoria packardi* Malloch**

*Hydrophoria packardi* Malloch, Ann. Mag. Nat. Hist., ser. 9, 14: 514, 1924; Ségué, Gen. Insect., Fasc. 205, p. 134, 1937.

This species belongs to the *frontata* segregate, closely resembling *frontata* itself. I have seen only a male specimen of the species, taken at Nairn, Labrador, which belonged to the collection of the Biological Survey of the United States Department of Agriculture. Unfortunately this specimen has become mislaid, and since my notes are too incomplete it is not possible at this time to discuss its relationships and taxonomy. The type was collected on Caribou Island, Labrador, according to its description.

<sup>14</sup>Ringdahl, O. Neue nordische Musciden nebst Berichtigung und Namensänderungen. Ent. Tidskr., 47 (2): 107, 1926.

A NEW SUBFAMILY OF BEETLES PARASITIC ON MAMMALS, STAPHYLINIDAE, AMBLYOPININAE, by CHARLES H. SEEVERS. Zool. Series, Field Museum of Natural History, Vol. 28, No. 3, pp. 155-172, pls. 10-12, 1944.

It has been known to Coleopterists since 1875 that Amblyopinus (South America) was frequently collected from rodents and marsupials, in some cases with its mandibles imbedded in the mammal's skin. Enough evidence has now been gathered to warrant the conclusion that it is a blood-sucking parasite. Seevers raises this genus to subfamily rank, reviews the genus, gives a key to the species and three plates on anatomy.—C. H. K.

# NEW SPECIES OF CRANE-FLIES FROM SOUTH AMERICA

## PART XI.<sup>1</sup> (Tipulidae, Diptera)

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The species described herewith are all from the vicinity of Mount Abitagua, Ecuador. The conditions obtaining around Abitagua have been briefly discussed in the preceding part under this title while still further notes concerning it are given by F. Martin Brown in his notable contribution to our knowledge of Ecuadorean Entomological Localities (Ann. Ent. Soc. America, 34: 809-851, 10 maps; 1941). The region has proved to be so prolific in species of insects that I have asked Mr. William Clarke-Macintyre, the collector of this and other rich series of Tipulidae, to describe it in somewhat more detail. I feel certain that the following supplementary notes concerning Mount Abitagua will be of much value to many students at this time and in the future.

"Mount Abitagua is really a low range of hills, beginning just east of the Rio Topo and extending along the Pastaza to the Rio Quilo, between here and Mera. The highest point of the range is called by the natives 'The Hill of Abitagua,' lying directly north of my place. This Abitagua Range at its highest point probably rises to 2,000 meters; there is then a rather broad plateau followed by a descent toward the north to a valley where rise the Rios Quilo, Mango Yacu and Anzu. North of this valley is the Llanganati Range of much higher hills, some of them snow-capped. I think that Abitagua is the remains of an old volcano although there is no lava or pumice in this immediate region; however, on the very highest point of the range there exists a small lake which from all descriptions must be an old crater lake. The slope of the 'Hill of Abitagua' comes down to the Pastaza between the Rios Abitagua and Ergano. The trail from Mera to Baños runs along a shoulder on that slope and takes quite a dip between the two rivers mentioned. Old earthquakes and landslides have shaped the hills into steps or shoulders.

"The Pastaza, which is 1800 meters above sea-level at Baños about 30 miles to our west has descended 800 meters during this distance. From here to Mera it descends about 100 meters more. At some places the last step or cliff descends abruptly to the river, almost forming a cañon, at other places leaving a sort of beach or 'playa' which varies in width from 10 to 100 meters. Excepting the Pastaza, the so-called rivers (Mera to Baños, east to west: Rio Ergano, Guillermino, Fox, Industria, Bella Vista and Abitagua) are really no more than small creeks, the larger ones about 10 meters wide where crossed by the trail.

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<sup>1</sup>Contribution from the Entomological Laboratory, Massachusetts State College.

The preceding part under this general title was published in the Annals of the Entomological Society of America, 36: 103-127, 1943.

From the trail to the Pastaza they have cut deep gorges, a fine collecting spot for certain rare Tipulidae and Odonata. In the Pastaza, immediately in front of my place, are two small islands, from one to two hectares in area. When the river is low, the channel between my shore and one of these islands is completely dry, with only a few stagnant pools of water. There is always water between the shore and the second island but for about one-half the time it is only ankle-deep and fordable. Just west of the Rio Industria the cliff has worn down to a gentle slope to the river, the only one along the entire road between Baños and Mera; everywhere else one has to climb down the bank to the lowest playa. There is no sedimentary rock in the soil of Abitagua. Geologists of the Royal Dutch Shell Company state that the core of the range is granite. Immediately in front of my house is a gravel pit and the soil is evidently alluvial as many of the stones are water-worn. Top-soil in no place is very deep, in some places non-existent. The only spot that is boggy is about one-half of Mayorga's Playa and about one-half of a pasture between the Rios Fox and Guillermino.

"The temperature here runs: 6 A. M.—16° C.; Noon—20–22° C.; 7 P. M.—17° C., with very little variation. The dry season, so-called, is from December to April but the only difference is that it rains more in the so-called wet season. Absolutely clear sunny days during the dry season average about eight per month, in the wet season about four or five. However even during the wet season it seldom rains all day, there generally being an hour or two of sun either in the morning or afternoon. It appears that each of the small streams or rios flowing into the Pastaza, as listed above, supports its own peculiar fauna, at least in certain groups of insects."—*William Clarke-Macintyre*.

### **Ozodicera** Westwood

#### **Ozodicera (Ozodicera) piatrix** sp. n.

General coloration dark brown, the scutellum, postnotum and pleura more pruinose; flagellar branches (male) subequal in length to the stems, simple; femora with a narrow, nearly apical, brownish black ring; wings with a strong grayish brown tinge, the prearcular and costal fields darker brown; stigma and a cloud on anterior cord conspicuously darker brown; male hypopygium with the basistyle produced at apex into an acute glabrous blackened spine; outer dististyle clavate, heavily blackened, the outer face of the apical club provided with abundant short erect setae.

*Male*.—Length, about 25 mm.; wing, 22 mm.; antenna, about 7 mm.

Frontal prolongation of head elongate, brownish black; nasus distinct; palpi black. Antennae (male) relatively long, brownish black, the pedicel and the incisures of the basal two or three flagellar segments very restrictedly paler; flagellar branches entirely simple and relatively short, subequal in length to but stouter than the segments themselves; simple terminal flagellar segments about equal in length to the remainder of antenna combined. Head dark grayish brown; anterior vertex narrow, about two-thirds the diameter of scape.

Pronotum brownish black. Mesonotum almost uniform dark brown, without distinct markings with the exception of a capillary more blackened vitta on cephalic portion of praescutum; scutellum and postnotum more heavily light gray pruinose. Pleura dark gray, the dorsopleural region still darker, more brownish black. Halteres black, the base of stem narrowly obscure yellow. Legs with the coxae gray pruinose; trochanters yellowish brown; femora obscure brownish yellow, each with a narrow, nearly apical, brownish black ring; tibiae brownish yellow, passing into black; tarsi black. Wings relatively narrow, with a strong grayish brown tinge, the prearcular region and cells *C* and *Sc* still darker brown; the narrowly oval stigma and a cloud on anterior cord conspicuously darker brown; veins light brown, somewhat darker in the costal portions. Venation: Cell *M*<sub>1</sub> rather broadly sessile.

Abdomen relatively long, black, sparsely pruinose, the basal tergal rings more reddish brown; hypopygium a little brightened. Ninth tergite of the male hypopygium with a small V-shaped median notch, the lateral lobes broadly truncated and provided with long setae. Basistyle produced at apex into a blackened glabrous spine, the tip acute. Outer dististyle heavily blackened, the basal half constricted, the apex expanded into an oval club provided with abundant short erect setae on outer face. Inner dististyle slender, curved, the apex terminating in two acute, slightly unequal spines; outer face of style near base produced into a stout triangular point and here provided with numerous very long and conspicuous yellow setae. Gonapophyses appearing as simple yellow rods subtending the shorter aedeagus, their tips acute.

*Holotype*, ♂, Abitagua, altitude 1,100 meters, May 26, 1941 (Macintyre); in spider's web.

*Ozodicera* (*Ozodicera*) *piatrix* is entirely different from the now relatively numerous species of the subgenus, differing especially in the structure of the male hypopygium, as the glabrous blackened spine of the basistyle and the darkened clavate outer dististyles. None of the regional species in Amazonian Peru, Ecuador or Brazil is closely allied.

## **Tanypremna** Osten Sacken

### **Tanypremna** (*Tanypremnella*) *mediocornis* sp. n. •

General coloration orange yellow, the thorax unpatterned; antennae (male) of moderate length, approximately one-half the length of body, the vestiture of the flagellar segments abundant and dense but short; legs dark brown, unpatterned; wings weakly tinted, stigma pale brown; *r-m* connecting with *Rs* at or just before the fork of the latter; male hypopygium with the spines of the inner dististyle relatively numerous, distributed over most of the extent of the style.

*Male*.—Length, about 12 mm.; wing, 13 mm.; antenna, about 5.6 mm.

Frontal prolongation of head obscure yellow; nasus long and conspicuous; palpi brown. Antennae (male) of moderate length, approximately one-half the length of body; scape and pedicel obscure

yellow, flagellum brownish black; first flagellar segment long-cylindrical, with abundant and dense short pubescence, the length of the setae less than the diameter of the segment; in *megacera*, the setae are long and coarse, the longest nearly three times the diameter of the segment. Head light brown, the front more brightened; anterior vertex relatively narrow, about two and one-half times the diameter of scape.

Pronotum testaceous yellow. Mesothorax almost uniform orange yellow, the pleura clearer yellow, the praescutum without distinct stripes; praescutal setae very small and sparse. Halteres elongate, black, the extreme base of stem yellow. Legs with coxae and trochanters yellow; remainder of legs dark brown or brownish black, the femoral bases not brightened. Wings subhyaline, a trifle more tinted than in either *microcera* or *megacera*; stigma pale brown; veins brown. Venation: *Rs* relatively short and straight; *r-m* at or just before its fork; cell 2nd *A* wider than in *microcera*.

Abdominal tergites chiefly brownish black, the basal rings obscure yellow, including about the basal third or slightly more; sternites more uniformly yellow, the posterior borders of the segments very weakly darkened; seventh and eighth segments more uniformly darkened, forming a subterminal dark ring; hypopygium yellow, the dististyles with darkened vestiture. Male hypopygium with the tergite large, the caudal margin convexly rounded to almost truncate across caudal border. Inner dististyle large and compressed, with abundant dark setae and about 18 short blackened spines that are well-distributed over most of the length of the style, not arranged in a small compact group of relatively few spines as in *megacera*; no flange on outer margin at base as in *microcera*.

*Holotype*, ♂, Abitagua, altitude 1,800 meters, April 15, 1940 (Macintyre).

The nearest allies of the present fly are *Tanypremna* (*Tanypremnella*) *megacera* Alexander and *T. (T.) microcera* Alexander, all three species having the thoracic pleura unvariegated and with no white color on legs. The antennae of the present fly are conspicuously shorter than in *megacera*, with the vestiture abundant but very short. All three species show marked differences in the structure of the male hypopygia, especially of the inner dististyle.

### Tipula Linnaeus

#### *Tipula osculata* sp. n.

Belongs to the *glaphyoptera* group; allied to *obirata*; mesonotal praescutum with three entire dark brown stripes, the interspaces yellow pollinose; antennae (male) short, the basal flagellar segments bicolored; femora brownish yellow, with a narrow, darker brown subterminal ring; wings yellow, heavily patterned with brown; prearcular field and a broad band before cord of the yellow ground; *R*<sub>1+2</sub> entire; male hypopygium with the posterior border of tergite produced into a short depressed lobe, the apex of which is evenly emarginate; gonapophyses at apex dilated into broad pale blades.



*Male*.—Length, about 13 mm.; wing, 14.5 mm.; antenna, about 2.5 mm.

Frontal prolongation of head above light brown, the sides darker brown; nasus slender; palpi dark brown. Antennae relatively short; basal three segments yellow; succeeding segments weakly bicolored, the scarcely indicated basal swelling dark brown, the distal half or more of segment yellow; outer segments uniformly dark brown; longest verticils considerably exceeding the segments in length. Head with central portion yellowish, the posterior vertex behind the eyes slightly darker; vertical tubercle low.

Pronotum obscure yellow, weakly darkened on sides. Mesonotal praescutum with interspaces yellow pollinose, the three stripes entire, dark brown, the lateral pair merging gradually with the brown lateral praescutal border; scutum dark brown, the central area obscure yellow, weakly more darkened behind the suture, scutellum obscure brownish yellow; mediotergite dark brown on central portion, more reddish brown on sides. Pleura and pleurotergite yellow, the meron a trifle darker. Halteres yellow. Legs with coxae and trochanters yellow; femora obscure brownish yellow, each with a very narrow, darker brown, subterminal ring; tibiae and basitarsi light brown, the outer tarsal segments blackened; legs very long and slender. Wings with the ground color yellow, heavily patterned with brown; the main ground areas include the entire prearcular field and a broad complete band before the cord; cell C a trifle more brownish yellow than is cell Sc; the chief dark areas include four subcostal spots, the first three extensive and produced behind into cell R; last area, in extreme end of cell Sc, small; a very large dark marking centers about cell 1st  $M_2$ , crossing the entire wing and only slightly variegated with paler spots; outer ends of cells  $R_5$  to  $M_4$ , inclusive, with yellow areas, the one in cell  $R_5$  very extensive, including the distal half of cell; basal of cord, cells Cu, 1st A and 2nd A with very extensive zigzag brown areas, these being posterior extensions of the three more basal subcostal darkened areas; veins yellow, dark in the patterned portions. Venation:  $R_{1+2}$  entire, the tip pale; petiole of cell  $M_1$  shorter than  $m$ .

Abdomen obscure brownish yellow, the basal tergites very weakly darkened medially, the outer tergites more uniformly darkened; hypopygium yellow. Male hypopygium with the tergite transverse, its caudal margin convex, the median portion produced into a short glabrous depressed lobe, the caudal border of which is evenly emarginate; dorsal surface of tergite with a median furrow. Basistyle small but complete, without lobes. Outer dististyle a slender cylindrical pale lobe. Inner dististyle relatively narrow, its outer lobe slender, the inner margin and apex of the inner lobe blackened. Gonapophysis at apex dilated into a broad pale blade.

*Holotype*, ♂, Abitagua, altitude 1,100 meters, June 8, 1941 (Macintyre).

*Tipula osculata* is most similar to species such as *T. consonata* Alexander, *T. juvenia* Alexander, and *T. obirata* Alexander, especially to the last. The combination of entire vein  $R_{1+2}$ , subterminal dark femoral

rings, nature of the wing pattern, and the structure of the male hypopygium readily serves to separate the present fly from these similar forms.

***Tipula hedymopa* sp. n.**

Belongs to the *glaphyoptera* group; allied to *jubilans*; mesonotal praescutum obscure brownish yellow, with a restricted dark brown pattern; femora yellow, with a narrow, nearly terminal, dark brown ring; wings bright yellow, handsomely but restrictedly patterned with brown, including washings and marblings in all cells beyond cord and in outer ends of Anal cells; cell *M* with the apical darkening along vein *Cu* conspicuous, the subapical spot correspondingly reduced.

*Female*.--Length, about 12 mm.; wing, 12.5 mm.

Frontal prolongation of head yellow; nasus stout, concolorous; palpi yellow, the terminal segment blackened. Antennae short; basal three segments light yellow; succeeding segments weakly bicolored, the scarcely developed basal enlargements very pale brown, the remainder yellow; verticils much longer than the segments. Head obscure brownish yellow; vertical tubercle very low to scarcely indicated.

Pronotum obscure testaceous yellow. Mesonotal praescutum obscure brownish yellow, sparsely golden-yellow pollinose, especially marked on the interspaces, the usual stripes scarcely differentiated except as follows: A triangular area on extreme cephalic portion and a restricted darkened cloud on border opposite the pseudosutural foveae; scutum yellow pollinose, each lobe with two brown areas, the one nearer the midline larger; scutellum yellow pollinose; postnotum testaceous yellow, the posterior border of the mediotergite restrictedly darkened. Pleura yellow, the anterior portion of the mesepisternum vaguely darker to produce a weak transverse girdle. Halteres yellow, the base of knob a trifle darker. Legs with the coxae and trochanters obscure yellow; femora obscure yellow with a narrow, nearly terminal, dark brown ring that is subequal in extent to the more reddish brown apex; tibiae brownish yellow basally, passing into brownish black; tarsi black. Wings with the ground color unusually bright yellow, especially the basal and costal portions; a rather restricted but conspicuous brown pattern, with slightly darker areas at *h* and arculus, origin of *Rs*, stigma and *m*; the very slightly paler brown areas include a small spot in cell *Sc*, mid-distant between arculus and origin of *Rs*, and washes and marblings in all cells beyond cord; outer end of cell *1st M*<sub>2</sub> and outer ends of both Anal cells slightly darkened; the subapical darkening in cell *M* adjoining vein *Cu* is reduced in size, as in *absona*, differing conspicuously from the major dark cloud found in *jubilans*; veins yellow, conspicuously darkened in the clouded areas. Venation: Tip of *R*<sub>1+2</sub> atrophied, including less than the distal third of the vein.

Abdominal tergites orange-yellow, the basal tergite clearer yellow; lateral borders of tergites with narrow interrupted black dashes, longest and most extensive on the second segment; sternites obscure yellow; cerci relatively slender.

*Holotype*, ♀, Abitagua, altitude 1,100 meters, June 4, 1941 (Macintyre).

The nearest relative among the described species is *Tipula jubilans* Alexander, which differs most conspicuously in the wing pattern. In *jubilans*, vein  $R_{1+2}$  is entire whereas in the present fly the tip is atrophied but this character may not prove to be constant.

*Tipula emerita* sp. n.

Belongs to the *monilifera* group; general coloration buffy yellow, the praescutum with three darker stripes, the median one paler and more or less distinctly split by a capillary dark line; antennae (male) elongate, nodulose, the basal swellings oval, not abruptly subglobular as in the typical members of the group; femora dark brown with a subterminal yellow ring; wings cream-yellow, heavily patterned with light and dark brown, including a series of four subcostal brown areas;  $R_{1+2}$  atrophied; basal abdominal segments yellow, the succeeding ones dark brown; eighth sternite unarmed.

*Male*.—Length, about 9–9.5 mm.; wing, 11–13 mm.; antenna, about 9–10 mm.

Frontal prolongation of head obscure yellow above, conspicuously dark brown on sides; nasus distinct, yellow; palpi black, the incisures restrictedly pale. Antennae (male) elongate, as shown by the measurements; basal three segments yellow; succeeding segments bicolored, the basal enlargements black, the pedicels brownish yellow, on the outer segments passing through brown to dark brown; basal swellings of segments oval, not abruptly globular or subglobular as in the typical members of the group; verticils long, approximately two-thirds the length of the segments; all flagellar segments densely clothed with shorter erect setae. Head buffy; vertical tubercle not or scarcely developed.

Pronotum buffy. Mesonotal praescutum with the ground color buffy yellow, with three brown stripes, the median one much paler on cephalic portion and, in cases, for the entire length, more or less distinctly split by a still darker median vitta; posterior sclerites of notum obscure buffy yellow, the centers of the scutal lobes, parascutella and a strong central line on mediotergite dark brown. Pleura obscure yellow, with a more or less distinct brown girdle occupying the cephalic portion of the mesepisternum. Halteres with stem obscure brownish yellow, the knob dark brown. Legs with the coxae and trochanters obscure yellow; femora obscure yellow basally, passing into dark brown, with a subterminal yellow ring that is slightly less extensive than the darkened tip; tibiae and tarsi dark brown to brownish black. Wings with the ground color cream yellow, conspicuously variegated by light and darker brown, the latter areas including four subcostal markings that are prolonged backwards across cells *R* and *M* to vein *Cu*, the second and third confluent behind; cells beyond cord and outer ends of Anal cells very extensively clouded with somewhat paler brown; veins dark brown. Venation:  $R_{1+2}$  entirely atrophied; petiole of cell *M*<sub>1</sub> a little longer than *m*.

Abdomen with basal two tergites obscure yellow, the first darkened on discal portion; succeeding segments, including hypopygium,

dark brown. Male hypopygium with the caudal margin of tergite with two shallow notches, one on either side of the slightly produced median portion which is extended into two short points separated by a shallow groove or notch; margins of the two major notches conspicuously fringed with setae. Caudal portion of basistyle, immediately below the dististyles, with an oval lobe that is densely covered with coarse setigerous tubercles. Outer dististyle slender. Inner dististyle parallel-sided on basal portion. Gonapophyses notched at tips, the outer spine largest. Eighth sternite unarmed.

*Holotype*, ♂, Abitagua, Mayorga's Playa, altitude 1,000-1,100 meters, April 12, 1940 (Macintyre). *Paratopotypes*, 6 ♂♂, April 12, 1940, June 6, 1941; *paratypes*, 2 ♂♂, Cunibunda, altitude 1,100 meters, April 7, 1940 (Macintyre).

*Tipula emerila* is very different from the normal *monilifera* type in the oval, more gradual, basal enlargements of the flagellar segments in the male. In this respect it is approached by the otherwise entirely distinct *T. procericornis* Edwards, from very high altitudes in Ecuador (3,800 meters and over). It is becoming evident that the so-called *monilifera* and *glaphyroptera* groups of the genus, as well as the subgenus *Microtipula* Alexander, all represented by abundant species in the Neotropics, are becoming closely interconnected by the discovery of numerous new forms. It seems probable that all eventually will be placed in the last-named subgenus, with the various groups being maintained chiefly for convenience in handling the great mass of species.

#### *Tipula luteilimbata* sp. n.

Size small (wing, 12 mm.); general coloration of thoracic notum pale brown, without pattern; antennae (male) very long, approximately three-fourths the length of wing, flagellum black; wings with a strong brownish tinge, sparsely patterned with darker brown, including a large cloud near outer end of cell *M*; cord, especially *m-cu*, bordered by yellow; male hypopygium with the tergite notched medially, the low lateral lobes set with many straight black pegs; outer dististyle a small dusky lobe bearing a blackened tooth on mesal face near base.

*Male*.—Length, about 10 mm.; wing, 12 mm.; antenna, about 9 mm.

*Female*.—Length, about 11 mm.; wing, 12 mm.; antenna, about 2.5 mm.

Frontal prolongation of head relatively short and stout, obscure brownish yellow above, darker beneath; nasus short and stout; palpi black. Antennae of male very long, of female moderately so; scape and pedicel yellow, flagellum black in male, dark brown in female; flagellar segments of male very elongate-cylindrical, with scarcely developed basal tubercles; verticils much shorter than the segments; besides the verticils, the entire segment bears abundant erect pale setae that are from two to three times as long as the diameter of the segments; a third type of delicate pubescence covers the entire surface of each segment. In the female, the three types of vestiture likewise occur but in slighter degree. Head with the front and anterior vertex light yellow, the posterior vertex dark brown, more intense adjoining the eyes; anterior vertex wide, the tubercle lacking.

Pronotum yellow. Mesonotum uniformly pale brown, without pattern; vestiture of praescutal interspaces exceedingly short and sparse. Pleura uniformly yellow. Halteres relatively long, dark brown, the extreme base of stem pale. Legs with coxae and trochanters yellow; remainder of legs obscure yellow, the outer segments passing into brownish black; claws short and strongly curved, simple in both sexes. Wings with a strong brownish tinge, the prearcular field, cells *C* and *Sc*, and the stigma darker brown, especially the last; a conspicuous brown cloud near outer end of cell *M*; restricted yellow areas, including a broad seam on either side of *m-cu*, with further similar but less conspicuous areas along anterior cord, before and beyond stigma, and just basad of the darkened area in cell *M*; veins brown. Abundant macrotrichia on veins beyond cord, more sparse on *M*<sub>1</sub>; squama glabrous. Venation: Tip of *R*<sub>1+2</sub> more or less atrophied, in the male with only a basal spur, in the female with about the basal half of the vein preserved; *M*<sub>3+4</sub> short to very short, subequal to *r-m*; cell 2nd *A* relatively wide.

Abdominal tergites chiefly dark brown, the sternites and hypopygium yellow. Ovipositor with cerci long and slender, nearly straight. Male hypopygium small and of simple construction. Ninth tergite transverse, the caudal margin with a broad V-shaped notch, the low lateral lobes with many straight black spinuous pegs. Outer dististyle a small dusky lobe, the mesal face near base with a short blackened tooth. Inner dististyle subequal in length to last but stouter, with two conspicuous black teeth on margin, beyond which point the style is produced into a flattened yellow blade. Gonapophyses appearing as simple flattened blades, the tips a little wider, obtuse.

*Holotype*, ♂, in poor condition, Abitagua, altitude 1,100 meters, April 12, 1940 (Macintyre). *Allotopotype*, ♀, altitude 1,800 meters, April 15, 1940.

*Tipula luteilimbata* is readily told from all of the numerous species of the genus by the peculiar wing pattern which is entirely different from that of other described forms. The structure of the antennae and the male hypopygium provide other distinctive features. Despite the structure of the ovipositor I am inclined to believe that the species should be referred to the subgenus *Nephrotomodes* Alexander, various members of which it most nearly resembles superficially.

#### ***Tipula (Nephrotomodes) cerogama* sp. n.**

Size large (wing, male, 14 mm. or more); antennae elongate; mesonotum brownish yellow without distinct markings; wings with a strong brown tinge, restrictedly patterned with still darker brown; conspicuous whitish subhyaline areas before stigma and across base of cell 1st *M*<sub>2</sub>; vein *R*<sub>1+2</sub> preserved; male hypopygium large and bulbous, the outer dististyle very large, earlike, the inner dististyle exceedingly small, in area less than one-tenth that of the outer style; no lobes in notch of ninth sternite.

*Male*.—Length, about 13–14 mm.; wing, 14–15 mm.; antenna, about 7–7.2 mm.

*Female*.—Length, about 15 mm.; wing, 17 mm.

Frontal prolongation of head obscure brownish yellow; nasus distinct; palpi pale brown. Antennae (male) moderately long; basal three segments obscure yellow, the remainder black; flagellar segments rather strongly incised; longest verticils about two-thirds the segments. Head fulvous brown; vertical tubercle not developed.

Pronotum and mesonotum almost uniform brownish yellow, without clearly defined markings; praescutal setae extremely small and sparse. Pleura clearer yellow. Halteres with stem and base of knob infuscated, apex of knob obscure yellow. Legs with the coxae and trochanters yellow; femora obscure brownish yellow; tibiae a little darker; tarsi brownish black; claws (male) toothed. Wings with a strong brown tinge, especially in the female, restrictedly patterned with darker brown and whitish subhyaline; the dark areas include the prearcular field behind cell *C*, all of cell *Sc*, stigma and conspicuous clouds along cord, most evident on *m-cu* and the distal section of *Cu*<sub>1</sub>; the whitened areas include two very evident obliterative areas, one before stigma, the second across the base of cell 1st *M*<sub>2</sub> extending into the base of cell *M*<sub>1</sub>; veins brown. Venation: *R*<sub>1+2</sub> entire; *Rs* arcuated, longer than *m-cu*, the latter close to the fork of the short *M*<sub>3+4</sub> or just beyond this point on *M*<sub>4</sub>; cell 2nd *A* relatively wide.

Abdominal tergites chiefly dark brown, especially medially, the outer segments slightly more brightened sublaterally; basal sternites yellow; a conspicuous black subterminal ring in male, involving segments seven and eight, together with the posterior portion of tergite six; hypopygium large and bulbous, uptilted, obscure yellow. Ovipositor with the valves very short and fleshy, setiferous, as in the subgenus. Male hypopygium with the tergite narrowed outwardly, the outer lateral angles produced into moderate sized lobes, the intervening caudal border truncate, provided with numerous black setae. Outer dististyle very large and complex, appearing as a compressed earlike blade, the apex obtuse; mesal face and a small curved lobe near base provided with abundant conspicuous black setae. Inner dististyle very small, in area less than one-tenth that of the outer style, appearing as a compressed blade, the narrow rostral portion blackened. Notch of ninth sternite only feebly emarginate, without lobes as is common in the subgenus. Eighth sternite relatively small, without lobes or appendages.

*Holotype*, ♂, Abitagua, altitude 1,800 meters, April 15, 1940 (Macintyre). *Allotopotype*, ♀, in copula with holotype. *Paratopotype*, 1 ♂.

*Tipula (Nephrotomodes) cerogama* is entirely different from the other regional species of the subgenus. In its general appearance it is somewhat similar to *T. (N.) palaeogama* sp. n., but differs in all details of wing pattern and structure of the male hypopygium.

#### ***Tipula (Nephrotomodes) palaeogama* sp. n.**

Size large (wing, male, 15 mm.); general coloration of mesonotum reddish brown, scarcely patterned; wings subhyaline to weakly darkened, heavily and conspicuously patterned with dark brown, including cells *C* and *Sc*, stigma, outer radial field and a broad seam on *m-cu*; male

hypopygium with the tergite elongate, strongly narrowed outwardly, the decurved apex produced into a blackened lobe set with strong black setae and spinous points; inner dististyle on outer margin bearing a strongly flattened black blade; appendage of ninth sternite paired, strongly compressed, densely setiferous.

*Male*.—Length, about 13 mm.; wing, 15 mm.; antenna, about 8 mm.

*Female*.—Length, about 18 mm.; wing, 18 mm.

Frontal prolongation of head obscure brownish yellow above, darker brown on sides and beneath; nasus elongate; palpi dark brown, the elongate terminal segment conspicuously whitened. Antennae (male) elongate, exceeding one-half the length of wing; scape, pedicel and base of first flagellar segment obscure yellow, the remaining segments black; flagellar segments moderately incised; longest verticils a little exceeding one-half the length of the segments. Head reddish brown, without distinct vertical tubercle.

Pronotum and mesonotum almost uniform reddish brown, the praescutum without clearly differentiated stripes; setae of praescutal interspaces relatively short; setae of scutellum and postnotum longer and more conspicuous. Pleura, pleurotergite and dorsopleural membrane uniformly pale yellow. Halteres infuscated, the apices of knobs a little brightened. Legs with coxae and trochanters pale yellow; femora dark brown, obscure yellow basally; tibiae and tarsi brownish black; legs long and slender; claws (male) toothed. Wings with the ground color subhyaline and weakly darkened, as described; heavily and conspicuously patterned with dark brown, including all of cells *C* and *Sc*; stigma; outer radial field as far caudad as vein  $R_{4+5}$ , deepest in the basal portions; a very broad seam on *m-cu*; outer end of cell *1st M*<sub>2</sub> and fork of  $M_{1+2}$ ; a restricted cloud at origin of *Rs*; prearcular field paler brown; the clearer ground areas include a major area before stigma and anterior cord, cell *M* and the basal portions of cells *Cu*, *1st A* and *2nd A*; veins brown. Venation:  $R_{1+2}$  entire; cell *1st M*<sub>2</sub> narrow; cell *2nd A* relatively wide. In the type, a tiny cell is cut off in the axil of cell *R*<sub>2</sub> by an adventitious crossvein just beyond vein *R*<sub>2</sub>; in female, venation normal.

Abdomen dark brown, the incisures of the segments narrowly obscure testaceous yellow; in male the subterminal segments uniformly dark brown; hypopygium yellow. Ovipositor with the cerci compressed and hairy, as common in the subgenus. Male hypopygium with the ninth tergite elongate, strongly narrowed and decurved at apex, on the outer deflected portion with a blackened structure densely set with strong black setae and spinous points. Outer dististyle flattened-compressed, parallel-sided, the tip obtuse, the outer end blackened. Inner dististyle with the beak slender, the posterior lobe with abundant dense setae and more scattered stronger bristles; outer margin of style bearing a black flattened blade. Appendage of ninth sternite paired, strongly flattened and compressed, densely set with long yellow setae. Eighth sternite with caudal margin rounded, on either side of median line with numerous elongate setae forming two distinct groups, the mid-region without major setae.

*Holotype*, ♂, Abitagua, altitude 1,800 meters, April 15, 1940 (Macintyre). *Allotopotype*, ♀, pinned with type.

*Tipula* (*Nephrolomodes*) *palaeogama* is entirely distinct from the now numerous species of the subgenus, differing especially in the wing pattern and in the structure of the male hypopygium. It rivals in size the largest known members of the subgenus, as *T. (N.) aymara* Alexander, of Bolivia.

### **Limonia Meigen**

#### **Limonia (Limonia) aurigena sp. n.**

Belongs to the *praeclara* group; general coloration brown, the mesonotum with a conspicuous, golden-yellow, dorsomedian stripe; antennal scape yellow, the remainder black; legs black, with two snowy white rings, one at tip of tibia, the second on tarsi, involving only the extreme tip of basitarsi, with the succeeding three segments; wings yellowish brown, restrictedly patterned with darker brown; male hypopygium with mesal-apical lobe of gonapophysis darkened, slightly curved at tip; apex of aedeagus small, only slightly expanded.

*Male*.--Length, about 6.8-7 mm.; wing, 7.2-7.5 mm.

Rostrum very reduced, yellow, tipped with black; palpi reduced, black. Antennae with scape pale yellow; pedicel and flagellum black; flagellar segments oval, the outer segments more elongate; all segments except the last with very short glabrous apical pedicels; terminal segment elongate, nearly twice the penultimate; longest verticils unilaterally distributed, exceeding twice the segments. Head with front and anterior vertex pale, silvery pruinose; posterior vertex brown; anterior vertex wide, approximately four times the diameter of scape.

Pronotum pale brown, slightly darker laterally. Mesonotum medium brown with a broad, golden-yellow, median stripe extending from the cephalic border of praescutum to the abdomen, gradually narrowed behind, ending as a point on the posterior border of mediotergite; on praescutum, the stripe more intense, more or less divided by a capillary dark line, the stripe bordered laterally by a more intense darkening of the ground color, this deepened pattern bordering the pale stripe continued more or less distinctly for the entire length of the mesonotum, the lateral borders distinctly paler. Pleura obscure brownish yellow, clearer yellow on most of sternopleurite. Halteres blackened. Legs with coxae and trochanters yellow; femora black, the extreme bases obscure yellow; tibiae black, the tips narrowly snow-white, the amount subequal on all legs and involving the distal seventh or eighth; basitarsi black, the extreme tips whitened; remainder of tarsi white, only the terminal segment again abruptly black. Wings with a rich yellowish brown suffusion, the costal border weakly darkened; a restricted darker brown pattern, including small spots at origin of *Rs*, fork of *Sc*, a very small stigmal area, cord and outer end of cell 1st *M*<sub>2</sub>; veins brown. Venation: *Sc*<sub>1</sub> ending nearly opposite two-thirds the length of *Rs*, *Sc*<sub>2</sub> at its tip; *Rs* angulated at origin; inner ends of cells *R*<sub>4</sub> and 1st *M*<sub>2</sub> about in transverse alignment and lying some distance basad of cell *R*<sub>4</sub>; *m-cu* close to fork of *M*.



Abdominal tergites brownish black, even more intense laterally; sternites light yellow; incisures of outer segments restrictedly pale; male hypopygium dark. Male hypopygium characteristic of the group; basistyle with ventromesal lobe low and stout, with numerous setae. Dorsal dististyle a strongly curved blade, slightly more widened on outer third. Ventral dististyle small, its rostral prolongation long and unusually glabrous, with a small oval sensory area close to tip. Gonapophysis with mesal-apical lobe darkened, slightly curved at tip. Apex of aedeagus relatively small, not modified into a large compressed blade or flange as is the case in several allied forms.

*Holotype*, ♂, Abitagua, Cunibunda, altitude 1,100 meters, April 2, 1940 (Macintyre). *Paratopotypes*, 2 ♂♂, with the type.

There are several allied species in the Neotropical fauna having snowy white to pale rings on the legs, such species including *Limonia* (*Limonia*) *capnora* Alexander, *L. (L.) curraniana* Alexander, *L. (L.) limbinervis* Alexander, *L. (L.) lutzi* Alexander, *L. (L.) metae* Alexander, *L. (L.) praeclara* Alexander and *L. (L.) trialbocincta* Alexander. The present fly is closest to *metae*, differing from this and other allies especially in the leg-pattern and in slight details of the male hypopygium, notably the gonapophyses and aedeagus. The structure of the ventral dististyle and its rostral prolongation is very characteristic of the entire group. It seems further evident that still other Neotropical species having unpatterned legs, including *L. (L.) fumosa* Alexander, *L. (L.) insularis* Williston, *L. (L.) grossa* Alexander, *L. (L.) infucata* Alexander, *L. (L.) mesotricha* Alexander, *L. (L.) multisignata* Alexander, and *L. (L.) pernobilis* Alexander, belong to this same group.

#### *Limonia* (*Geranomyia*) *stenophallus* sp. n.

General coloration of mesonotum reddish, the praescutum with three diffuse, more reddish brown stripes, the lateral praescutal borders weakly darkened; knobs of halteres dark brown; wings pale yellow, restrictedly patterned with brown; *Sc* relatively long; *Rs* angulated and spurred at origin; dark areas at origin of *Rs* and fork of *Sc* separate; male hypopygium with the rostral prolongation short, truncated at apex, the two long rostral spines arising from low separate tubercles; gonapophyses with mesal-apical lobes produced into blackened spines; aedeagus unusually long and slender, narrowest at near midlength.

*Male*.—Length, excluding rostrum, about 6 mm.; wing,  $\frac{7}{8}$  mm.; rostrum, about 3 mm.

Rostrum relatively long, about one-half the length of body, black, the tips of labial palpi a very little paler. Antennae black throughout; flagellar segments oval to long-oval; verticils of moderate length. Head black; a narrow silvery line extending from the front over the vertex to the occiput, its width equal to the diameter of the anterior vertex.

Pronotum obscure yellow. Mesonotal praescutum with the ground color reddish gray, with three diffuse, more reddish brown stripes that are only poorly indicated and defined, subequal in width to the posterior interspaces; lateral praescutal borders weakly

darkened; scutum reddish brown; scutellum and postnotum obscure yellow; vestiture of notum much reduced. Pleura testaceous yellow, the dorsopleural membrane and dorsal sclerites a trifle darker. Halteres with stem pale, knob dark brown. Legs with coxae and trochanters yellow; remainder of legs broken. Wings with the ground color pale yellow, rather sparsely patterned with brown, including the oval stigma and seams at the supernumerary crossvein in cell *Sc*; origin of *Rs*; fork of *Sc*, the latter much smaller than the former and entirely separate from it; conspicuous seams along cord and outer end of cell *1st M*<sub>2</sub>; veins pale, darker in the patterned areas. Costal fringe short and dense. Venation: *Sc* of moderate length, *Sc*<sub>1</sub> ending opposite midlength of *Rs*, *Sc*<sub>2</sub> near its tip; *Rs* angulated and short-spurred at origin; basal section of *R*<sub>4+5</sub> long, shortening *r-m*; cell *1st M*<sub>2</sub> a little shorter than the distal section of *M*<sub>1+2</sub>; *m-cu* a short distance beyond the fork of *M*; vein *2nd A* sinuous.

Abdomen with tergites pale brown or yellowish brown, provided with long conspicuous setae; sternites somewhat paler; hypopygium brownish yellow. Male hypopygium with the tergite relatively long, its caudal border only gently emarginate, the low lateral lobes provided with several long black setae. Basistyle with the ventromesal lobe relatively long but simple. Dorsal dististyle a gently curved rod, its tip abruptly narrowed into a spine. Ventral dististyle fleshy, its area about twice that of the basistyle; rostral prolongation short and stout, the apex truncate; two long rostral spines from very long separate tubercles, placed side by side on basal half of prolongation; spines long and slender, about twice as long as the prolongation. Gonapophyses with mesal-apical lobe produced into a slender acute blackened spine. Aedeagus unusually long and slender, narrowest near midlength, the distal half dilated to about twice its width at the narrowest point, the apex weakly bilobed.

*Holotype*, ♂, Abitagua, Mayorga's Playa, altitude 1,100 meters, April 12, 1940 (Macintyre).

Despite its very different general appearance, especially the wing pattern, I believe the nearest relative of the present fly is *Limonia* (*Geranomyia*) *hirsutinota* Alexander, which has the general structure of the male hypopygium much as in the present fly though differing in details.

#### *Limonia* (*Geranomyia*) *refuga* sp. n.

General coloration of mesonotum orange, including the disk of praescutum and the scutal lobes; scutellum testaceous; knobs of halteres dark brown; wings yellow, very sparsely patterned with brown, including the oval stigma and restricted seams at origin of *Rs* and over the supernumerary crossvein in cell *Sc*; vein *Sc* short, *Sc*<sub>1</sub> ending just beyond the origin of *Rs*; cell *1st M*<sub>2</sub> subequal in length to vein *M*<sub>1+2</sub> beyond it; male hypopygium with the rostral spines arising from separate tubercles, these spines slightly unequal in diameter and length; gonapophyses with a conspicuous flange on the concave face of the mesal-apical lobe.

*Male*.—Length, excluding rostrum, about 6 mm.; wing, 7 mm.; rostrum, about 2.2 mm.

Rostrum black throughout, of moderate length. Antennae black; flagellar segments cylindrical to subcylindrical. Head dark brownish gray; anterior vertex reduced to a capillary line.

Pronotum obscure yellow. Mesonotal praescutum with the entire disk occupied by three confluent orange stripes, the humeral region restrictedly more yellow; scutal lobes similarly orange, the median region and the scutellum more testaceous; postnotum testaceous yellow; praescutum and scutum with sparse but very long and conspicuous erect setae, most evident near suture. Pleura yellow. Halteres with stem yellow, knob dark brown. Legs with coxae and trochanters yellow; remainder of legs broken. Wings with the ground color yellow, very sparsely patterned with brown, including the oval stigma, a small seam at the supernumerary crossvein in cell *Sc* and a restricted common seam at origin of *Rs* and fork of *Sc*; no distinct darkening along cord or outer end of cell *1st M*<sub>2</sub>. Costal fringe short and dense. Venation: *Sc* short, *Sc*<sub>1</sub> ending immediately beyond the origin of *Rs*, *Sc*<sub>2</sub> at its tip; cell *1st M*<sub>2</sub> elongate, subequal to vein *M*<sub>1+2</sub> beyond it; *m-cu* more than one-third its length beyond the fork of *M*.

Abdominal tergites obscure brownish yellow; sternites clearer yellow. Male hypopygium with the caudal margin of tergite broadly and shallowly emarginate, the low lobes with long coarse setae. Basistyle with the ventromesal lobes large, simple. Dorsal dististyle appearing as a gently curved sickle, the tip acute. Ventral dististyle very large, fleshy, in area nearly four times the basistyle; rostral prolongation relatively slender, with two rostral spines from separate tubercles, the outer spine a little longer and more slender, from a smaller tubercle; inner spine close to the base of the prolongation. Gonapophysis with mesal-apical lobe elongate, gently curved, pale, the concave face with a conspicuous flange.

*Holotype*, ♂, Abitagua, altitude 1,100 meters, March 21, 1940 (Macintyre).

*Limonia (Geranomyia) refuga* is very different from other regional species having a short *Sc* and restrictedly patterned wings. The immaculate praescutum separates it from several species having three narrow brown stripes on the praescutum. The nature of the hypopygium is most like that of *L. (G.) myersiana* Alexander, of the Greater Antilles, which has the wings unpatterned except for the stigma, and the details of body coloration distinct.

#### *Limonia (Geranomyia) pastazina* sp. n.

General coloration of mesonotum brownish yellow or testaceous brown, unmarked; rostrum elongate, black; halteres uniformly blackened; wings subhyaline, the cells beyond cord weakly darkened; stigma oval, dark brown, conspicuous; *Sc*<sub>1</sub> ending about opposite two-fifths the length of *Rs*; cell *2nd A* relatively narrow, vein *2nd A* gently and evenly arched throughout its length, not at all sinuous; male hypopygium with the apex of the dorsal dististyle narrowly obtuse; rostral spines of ventral dististyle arising from small individual tubercles; mesal-apical lobe of gonapophysis very long and slender, entirely pale.

*Male*.—Length, excluding rostrum, about 5 mm.; wing, 5.5 mm.; rostrum, about 2.5 mm.

Rostrum elongate, fully one-half the length of remainder of body, black. Antennae brownish black throughout; flagellar segments oval. Head dark brown, without pattern; anterior vertex reduced to a narrow strip that is narrower than the diameter of the scape.

Mesonotal praescutum, scutum and postnotum uniform brownish yellow or testaceous brown; scutellum broad, a trifle paler than the remaining sclerites of notum; notal setae very reduced to virtually lacking. Pleura testaceous yellow. Halteres uniformly blackened. Legs with coxae and trochanters testaceous yellow; remainder of legs broken. Wings subhyaline, the cells beyond cord weakly darkened; stigma oval, dark brown, conspicuous; veins brown. Venation: *Sc* of moderate length, *Sc*<sub>1</sub> ending about opposite two-fifths the length of *Rs*, *Sc*<sub>2</sub> at its tip; a supernumerary crossvein in cell *Sc*; basal section of *R*<sub>4+5</sub> in approximate longitudinal alignment with *Rs*; cell 1st *M*<sub>2</sub> subequal in length to or slightly shorter than vein *M*<sub>1+2</sub> beyond it; *m-cu* at or close to fork of *M*; cell 2nd *A* relatively narrow, the vein evenly and gently arched throughout its length.

Abdomen with tergites brown, the sternites brightened; hypopygium conspicuously darker, especially the ventral dististyle. Male hypopygium with the caudal margin of ninth tergite with a very broad U-shaped notch. Dorsal dististyle a strongly curved sickle, the tip narrowly obtuse. Ventral dististyle very large, exceeding three times the area of the basistyle; rostral prolongation short, truncated at apex, the spines long and conspicuous, more than twice as long as the prolongation itself, arising from small individual tubercles that are placed close together a short distance back from apex of prolongation; spines subequal in length but one more curved, both acute at tips. Gonapophyses entirely pale, the mesal-apical lobes very long and narrow, gently curved to the acute tips.

Holotype, ♂, Abitagua, Mayorga's Playa, altitude 1,100 meters, April 12, 1940 (Macintyre).

*Limonia (Geranomyia) pastazina* is evidently most closely related to members of the *canadensis* group, as *L. (G.) argentinensis* (Alexander), *L. (G.) austroandina* Alexander, and *L. (G.) guatemalensis* (Alexander), all of which have vein 2nd *A* sinuous and not evenly arcuated throughout its length, and with conspicuously elongated basal tubercles to the rostral spines of the ventral dististyle.

### **Epiphragma Osten Sacken**

#### **Epiphragma (Epiphragma) phaeoxantha sp. n.**

Mesonotal praescutum rich chestnut brown, the posterior sclerites darker; thoracic pleura with a broad yellow longitudinal stripe extending from the pronotum to beneath the wing root, clearly separated from a black pleural stripe immediately beneath it; legs yellow, the femora with two conspicuous dark brown rings; wings yellow, heavily marked with brown, the pattern in part ocelliform.

*Male*.—Length, about 8 mm.; wing, 7.5 mm.

Rostrum and palpi black. Antennae with the scape and pedicel weakly infuscated to obscure yellow; fusion-segment of flagellum yellow; succeeding segments brownish black; antennae broken beyond the tenth segment; flagellar segments long-cylindrical, with conspicuous verticils that are subequal in length to the segments; antennae relatively short. Head orange-yellow, the posterior vertex more testaceous, with a central infuscation.

Pronotum light yellow, the color continued caudad as a very broad and conspicuous longitudinal stripe to below the wing-root, becoming wider behind, involving the extreme lateral border of praescutum, the dorsopleural membrane and the dorsal portions of the thoracic pleura, the stripe behind involving the dorsal pteropleurite and pleurotergite. Mesonotum rich chestnut brown, the disk not or scarcely patterned, the lateral border conspicuously blackened; scutal lobes chestnut brown, the median area weakly darkened; scutellum and postnotum more strongly infuscated, sparsely pruinose, the lateral portions of mediotergite and adjoining portions of pleurotergite extensively obscure yellow. Pleura beneath the yellow dorsal stripe with a comparable longitudinal black stripe, its upper edge clear-cut, the ventral portion merging with the obscure yellow of the ventral sternopleurite and meron. Halteres yellow. Legs with the coxae yellow, the fore pair weakly darkened, especially on proximal portions; trochanters yellow; legs detached; femora yellow, each with two conspicuous dark brown rings, the outer one narrower than the yellow ring on either side; tibiae and tarsi yellow. Wings relatively broad; ground color yellow, the prearcular and costal fields more saturated yellow; a heavy brown pattern that is in part ocelliform, including a complete ring at origin of *Rs*; incomplete rings at arculus, along cord and fork of  $M_{1+2}$ ; cell *Cu* with a single dark cloud at near midlength; outer margin of cell 1st *A* with two dark dashes, cell 2nd *A* with five, the innermost a larger cloud that extends into the base of cell 1st *A*; dark area over the supernumerary crossvein in cell *C* not connected with other brown spots; veins yellow, a little darker in the patterned areas. Venation:  $R_{2+3+4}$  relatively short, a trifle less than two times *r-m*; *m-cu* more than three-fourths its own length beyond the fork of *M*.

Basal abdominal tergites chiefly obscure yellow, patterned with brown, the outer segments more extensively darkened; tergal impressions more yellowish; basal sternites obscure yellow, the outer segments more darkened; hypopygium obscure yellow. Male hypopygium with the interbasal rods strongly recurved at their tips.

*Holotype*, ♂, Abitagua, Cunibunda, altitude 1,100 meters, March 22, 1940 (Macintyre).

The broad yellow stripe on the pronotum and dorsal thoracic pleura readily separates the present fly from other regional allies. Among the now numerous Neotropical species of the genus, the closest relatives appear to be *Epiphragma* (*Epiphragma*) *amphileuca* Alexander and *E. (E.) delicatula* Osten Sacken. It is unfortunate that the apical segments of the antennae of the unique type are broken and thus it cannot be stated whether or not the outer antennal segments are abruptly whitish, as is the case in *amphileuca* and certain other species.

**Ctenolimnophila** Alexander**Abitagua** subgen. n.

Characters as in the typical subgenus. Antennae 15-segmented; scape elongate; basal five flagellar segments united into an elongate fusion-segment, the former sutures feebly indicated, each ring thus formed with a strong bristle; sixth flagellar segment partly fused with the basal segment; succeeding seven segments more elongate, the terminal one nearly twice the penultimate; all outer segments with long verticils, including a unilaterally arranged series consisting of a single, unusually long seta on each segment, the longest bristle fully three times the segment alone. Halteres elongate. Tibiae with two strong spurs; claws simple. Wings with anterior arculus broken; vein  $R_{2+3+4}$  very long,  $R_2$  lacking; cell  $M_1$  lacking; cell  $1st\ M_2$  very long and narrow, with  $m-cu$  at near midlength. Male hypopygium with the outer dististyle terminating in a simple truncated point; inner dististyle provided with conspicuous spines and spinous points; gonapophyses appearing as pale clubs, their tips set with numerous appressed spines.

*Type of Subgenus*.—*Ctenolimnophila* (*Abitagua*) *longifusa* sp. n. (Neotropical Region).

**Ctenolimnophila** (*Abitagua*) *longifusa* sp. n.

General coloration of notum light chestnut brown, without pattern; thoracic pleura with a conspicuous black longitudinal stripe; halteres elongate, yellow; legs black, the tarsi paling to obscure yellow; wings uniform pale brown, unpatterned;  $R_{2+3+4}$  and cell  $1st\ M_2$  unusually long; male hypopygium with the inner dististyle conspicuously spinous.

*Male*.—Length, about 6.5 mm.; wing, 6.3 mm.; antenna, about 1 mm.

Rostrum and palpi black. Antennae with scape and pedicel black, flagellum pale brown. Head brown.

Pronotum and pretergites obscure yellow. Mesonotum almost uniformly light chestnut brown, without distinct pattern. Pleura light brownish yellow with a conspicuous black longitudinal stripe extending from the cervical region to the base of abdomen. Halteres unusually long, with small club, yellow throughout. Legs with the coxae and trochanters brownish yellow; remainder of legs black, the tarsi paling to obscure yellow. Wings with a uniform pale brown tinge, without pattern. Veins beyond cord with abundant long trichia. Venation:  $Sc_1$  ending opposite fork of  $Rs$ ,  $Sc_2$  near its tip;  $Rs$ ,  $R_{2+3+4}$  and  $R_3$  all elongate and generally equal in length; inner end of cell  $1st\ M_2$  lying far basad of cell  $R_4$ ;  $m$  and basal section of  $M_3$  in approximate transverse alignment; cell  $2nd\ A$  moderately wide.

Abdomen weakly bicolored, obscure brownish yellow, the incisures and lateral borders more strongly blackened. Male hypopygium as described under the subgenus; outer dististyle entirely sclerotized and blackened, relatively narrow and parallel-sided, the apex narrowed into a decurved point, the apex truncated; inner dististyle much stouter, the entire outer face set with conspicuous blackened

appressed spines; apex of style terminating in three or four long powerful setae. Aedeagus broadly dilated at base.

*Holotype*, ♂, Abitagua, altitude 1,100 meters, June 13, 1941 (Macintyre).

The present fly superficially is most like *Ctenolimnophila* (*Campbellomyia*) *neolimnophiloides* Alexander, of southeastern Brazil, and it is possible that this latter fly will be found to belong to the new subgenus as above defined. The elongate vein  $R_{2+3+4}$  and the fusion segment of the antennae suggest the conditions found in the genus *Neolimnophila* Alexander but from the structure of the male hypopygium it is certain that there is no close relationship between these two groups. The typical members of both *Ctenolimnophila* and *Campbellomyia* Alexander have the antennal segments simple and unfused and it seems probable that when more material becomes available *Abitagua* will require full generic ranking.

### **Atarba Osten Sacken**

#### **Atarba (Atarba) procericornis sp. n.**

General coloration of thorax testaceous yellow, not or scarcely patterned; antennae (male) exceeding in length either the body or the wing; basal flagellar segments bicolored, their proximal ends yellow, the apices black; flagellar segments long-cylindrical, with conspicuous outspreading verticils; legs yellow; wings tinged with brown, the stigma slightly darker; *m-cu* about one-third its own length beyond the fork of *M*; abdominal tergites weakly bicolored, their bases yellow, the apices more broadly dark brown; male hypopygium with both dististyles unusually long, the outer at near one-third its length dilated into a triangular body, the long slender apex with seven or eight strong spines along outer border; inner dististyle unusually slender; aedeagus short and straight, unmodified.

*Male*.—Length, about 5 mm.; wing, 5.6 mm.; antenna, about 6.5 mm.

Rostrum testaceous yellow, with very long and conspicuous black setae; palpi dark brown. Antennae (male) exceeding the body in length, as shown by the measurements; scape and pedicel yellow; flagellar segments with the bases yellow, the tips black; on the first and second segments the two colors are about equal in extent, on the third and succeeding segments the amount of yellow progressively restricted, on segment three occupying one-third the segment, on segment five about one-fifth, on the seventh and eighth segments virtually lacking, the succeeding segments uniformly black; flagellar segments long-cylindrical, with conspicuous outspreading verticils over their total length. Head brown, very sparsely pruinose; eyes large; anterior vertex about one-half wider than the diameter of scape.

Pronotum and mesonotum almost uniform testaceous yellow, not or scarcely patterned. Pleura testaceous yellow, the dorsal sclerites a trifle darker. Halteres yellow, the knobs weakly darkened. Legs yellow, the outer tarsal segments passing into brown; tibiae spurred. Wings relatively narrow, tinged with brown, the prearcular and costal fields light yellow; stigma narrow, pale brown; veins and crossveins

very narrowly and insensibly seamed with darker; veins brown, yellow in the brightened portions. Venation:  $Sc_1$  ending opposite origin of  $R_s$ ,  $Sc_2$  some distance from its tip,  $Sc_1$  alone exceeding one-half the length of the relatively short  $R_s$ ;  $R_s$  very gently arcuated, its branches long and straight; cell  $1st\ M_2$  short, subquadrate;  $m-cu$  about one-third its length beyond the fork of  $M$ .

Abdominal tergites weakly bicolored, the bases obscure yellow, the apices more broadly dark brown, the subterminal segments more uniformly dark brown; hypopygium obscure brownish yellow, the styli darkened. Male hypopygium with the basistyle moderately long, on mesal face before apex with a small finger-like lobe; mesal face near base with a group of from eight to ten unusually strong and powerful setae. Outer dististyle long and narrow, at near one-third the length dilated into a triangular body that terminates in a strong spine; outer two-thirds of style slender, its outer border with about seven or eight strong spines before the decurved terminal one. Inner dististyle a little longer than the outer, unusually long and slender, gently curved at about one-third the length. Aedeagus straight, relatively short, moderately stout, the tip truncated and unmodified; at base of aedeagus on either side with two strong spinous points, the outermost again unequally hispinous; the exact homologies of these spines cannot be determined from the material available. No evident appendage of the ninth sternite is visible in the unique slide.

*Holotype*, ♂. Abitagua, Cunibunda, altitude 1,100 meters, April 2, 1940 (Macintyre).

*Atarba (Atarba) procericornis* is readily told from all of the now numerous Neotropical members of the genus by the very long antennae of the male and by the structure of the male hypopygium, especially the outer dististyle and the unusually slender inner dististyle. The most similar of these regional forms are *A. (A.) idonea* Alexander and *A. (A.) tatei* Alexander.

### **Gnophomyia** Osten Sacken

#### **Gnophomyia (Gnophomyia) coxitalis** sp. n.

General coloration black; antennae (male) relatively elongate, black throughout; halteres and legs black; wings with a strong blackish suffusion, vein  $Cu$  and the cord broadly seamed with darker;  $m-cu$  about opposite midlength of cell  $1st\ M_2$ ; male hypopygium with the lateral angles of ninth tergite produced caudad into long lobes, the margin between these with a comb of long spinous setae; basistyle on mesal face near proximal end with a row of about five very powerful black spinous setae.

*Male*.—Length, about 5.3–5.5 mm.; wing, 5.2–5.6 mm.; antenna, about 2.5–2.7 mm.

Rostrum and palpi black. Antennae relatively long, nearly one-half the length of wing, black throughout; flagellar segments elongate-oval; longest verticils exceeding the segments in length. Head black, broad, the anterior vertex about three times the diameter of scape.



Pronotum black; anterior lateral pretergites very restrictedly brightened. Mesonotum black, the surface opaque or subopaque. Pleura black, the surface sparsely pruinose. Halteres black. Legs with the coxae black, sparsely pruinose; trochanters brownish black; remainder of legs black, the bases of femora, especially the fore pair, restrictedly obscure yellow. Wings with a strong blackish suffusion, more heavily seamed with brown as a broad band at and beyond cord and as a conspicuous cloud along vein *Cu* in cell *M*; stigma narrowly long-oval, still darker in color; a more or less distinct subhyaline brightening in outer ends of cells *R* and *M* before the darkened cross-band; veins black. Venation: *Sc* long, *Sc*<sub>1</sub> ending a short distance before fork of *R*<sub>2+3+4</sub>, *Sc*<sub>2</sub> some distance from its tip, about opposite two-thirds the length of *Rs*; *Rs* straight, in alignment with *R*<sub>1</sub>, the basal section of the latter eliminated or virtually so; *R*<sub>2+3+4</sub> only slightly arcuated, in longitudinal alignment with its anterior branch; *R*<sub>2</sub> about one-half *R*<sub>2+3</sub>; cell 1st *M*<sub>2</sub> of moderate length, about one-half of vein *M*<sub>1+2</sub> beyond it; *m-cu* at near midlength of cell 1st *M*<sub>2</sub>; cell 2nd *A* of moderate length.

Abdomen, including hypopygium, black. Male hypopygium with the tergite transverse, its caudal margin with a dense comb of elongate black spinous setae; lateral angles of tergite greatly produced into long lobes that are provided with shorter, more appressed, spinous setae. Basistyle relatively short, the mesal face of each near base with a row of about five very powerful black spinous setae. Outer dististyle nearly straight, broadest on basal third, the apex subacute. Inner dististyle much smaller, blackened, gently arcuated, the distal end subtriangularly dilated, its apex obtuse. Phallosomic plate conspicuously bilobed.

*Holotype*, ♂, Abitagua, altitude 1,100 meters, March 21, 1940 (Macintyre). *Paratopotype*, ♂, with the type.

*Gnophomyia* (*Gnophomyia*) *coxitalis* is most nearly allied to *G. (G.) kertesiana* Alexander, *G. (G.) maestitia* Alexander, and *G. (G.) pallidapex* Alexander, differing from all in the peculiar structure of the male hypopygium, notably of the ninth tergite and the armed basistyles (coxites, parameres).

### *Gnophomyia* (*Gnophomyia*) *teleneura* sp. n.

General coloration of mesonotum black, the praescutum virtually covered by a continuous dorsal shield; pleura yellow, the anepisternum with a conspicuous blackened spot that includes the entire sclerite or virtually so; wings yellowish subhyaline, the central cells washed with brown to about the level of the darker brown stigma; costa opposite stigma conspicuously thickened; cord of wing lying unusually basad, at about midlength of wing, the veins beyond being very long; *M*<sub>1+2</sub> distad of the unusually narrow cell 1st *M*<sub>2</sub> about three times the length of the cell; cell 2nd *A* wide; male hypopygium with numerous very long strong setae on ninth sternite; outer dististyle slender, its tip obtuse.

*Male*.—Length, about 6.5 mm.; wing, 6.1 mm.; antenna, about 2 mm.

*Female*.—Length, about 6 mm.; wing, 6.2 mm.

Rostrum pale yellowish brown; palpi black. Antennae relatively long, as shown by the measurements; scape brown; pedicel and flagellum black; basal flagellar segments long-cylindrical, with relatively inconspicuous verticils; outer segments gradually shorter, the verticils longer and more conspicuous but still shorter than the segments; terminal segment small, about two-thirds the penultimate. Head gray.

Pronotum dark brown, pale laterally; pretergites pale yellow. Mesonotal praescutum covered by a polished black shield, the humeral region extensively yellow; region of suture, median area of scutum and the posterior border of scutellum more reddish, the remainder of mesonotum, including the pleurotergite, black. Pleura yellow, the anepisternum covered by a conspicuous circular blackened spot. Halteres with stem brown, knob blackened. Legs with the coxae and trochanters yellow; femora pale brown to yellowish brown; tibiae and tarsi obscure brownish yellow, the tips of tibiae and the outer tarsal segments restrictedly blackened. Wings yellowish subhyaline, distinctly patterned with darker; a heavy brown infuscation extending from the axillary region to beyond the cord, involving the extensive basal portions of cells *1st A*, *Cu* and *M*, as well as the bases of the outer radial cells to the general level of the stigma, the outer cells of wing somewhat less distinctly darkened; stigma oval, dark brown, conspicuous; prearcular field and costal region light yellow; veins brown, yellow in the brightened portions. Venation: In male, cord of wing lying unusually far basad, at midlength of wing, the veins beyond cord thus of unusual length; costa opposite the stigmal area strongly incassated and darkened; *R*<sub>5</sub> in longitudinal alignment with *R*<sub>4</sub>; *R*<sub>2</sub> relatively faint; *R*<sub>2+3+4</sub> about three times *R*<sub>2+3</sub>; cell *1st M*<sub>2</sub> very long and narrow, about one-third as long as vein *M*<sub>1+2</sub> beyond it; *m-cu* faint, slightly less than its own length beyond the fork of *M*; distal section of *Cu*<sub>1</sub> very long, cell *M*<sub>4</sub> correspondingly very deep; vein *2nd A* strongly arched on basal third, approaching vein *1st A*, cell *2nd A* wide. In female, venation about as in male but *R*<sub>2+3+4</sub> and veins beyond cord a trifle shorter; *m-cu* more evident, lying farther distad, at near one-third the length of cell.

Abdominal tergites dark brown, the sternites obscure brownish yellow, vaguely patterned with darker; hypopygium and preceding segment a little paler than the tergites. Male hypopygium with the sternite provided with about seven or eight very powerful setae arranged in a loose group on either side of midline, the setae directed ventrad. Outer dististyle relatively slender, its tip obtuse. Inner dististyle a compact mass consisting of a basal blackened lobe provided with a few long strong setae and an outer apical portion with apex obtuse, the margin roughened. Ovipositor with cerci relatively elongate, somewhat parallel-sided, with setae over the entire length; tips obtuse.

*Holotype*, ♂, Abitagua, altitude 1,800 meters, April 15, 1940 (Macintyre). *Allolotopotype*, ♀, with the type.

*Gnophomyia (Gnophomyia) teleneura* is entirely distinct from all other regional members of the genus, the most striking character being

the position of the cord at near midlength of the wing and the corresponding very unusual length of the veins beyond. The wing pattern is likewise distinctive of the species.

***Gnophomyia (Gnophomyia) flebilis* sp. n.**

General coloration black, the meral region of the thoracic pleura more yellow; antennae and legs brownish black; halteres with stem darkened, knob light yellow; wings with a very strong and uniform brown tinge, the prearcular field restrictedly yellow;  $Sc_2$  far from the tip of  $Sc_1$ , before the level of the fork of  $Rs$ ; male hypopygium with the outer dististyle long and slender, gradually narrowed to the subacute tip; inner dististyle short and stout, with a strong blackened tooth at base.

*Male*.—Length, about 5.2–5.5 mm.; wing, 5.3–6 mm.; antenna, about 1.1–1.2 mm.

*Female*.—Length, about 5.5 mm.; wing, 5.5 mm.

Rostrum and palpi black. Antennae black throughout, relatively short; flagellar segments subcylindrical, the longest verticils exceeding the segments in length. Head dull brownish black.

Pronotum black, the pretergites yellow. Mesonotum black, the surface glabrous and subnitidous. Pleura black, the more ventral pleurites paler and sparsely pruinose; meral region more yellowed. Halteres with stem brown, knob conspicuously light yellow. Legs with the fore and hind coxae testaceous, middle coxae darker; trochanters obscure yellow; remainder of legs brownish black to black, the femoral bases restrictedly brightened. Wings with a very strong and uniform brown tinge, the prearcular field restrictedly yellow; veins brownish black. Venation:  $Sc_1$  ending beyond midlength of  $R_{2+3+4}$ ,  $Sc_2$  far from its tip, shortly before the fork of  $Rs$ ;  $R_2$  very faint to subatrophied, placed shortly beyond the fork of  $R_{2+3+4}$ , varying from longer to shorter than vein  $R_{2+3}$  alone;  $m-cu$  variable, from one-third to nearly its own length beyond the fork of  $M$ .

Abdomen, including hypopygium and genital shield of ovipositor black. Male hypopygium with the outer dististyle unusually long and slender, gradually narrowed outwardly, the apex subacute to narrowly obtuse. Inner dististyle short and stout, obtuse at tip, only about one-third the length of outer style; at base of inner style with a strong blackened tooth or flange. Major plate of phallosome at apex narrowed into a median blackened point.

*Holotype*, ♂, Abitagua, altitude 1,100 meters, March 21, 1940 (Macintyre). *Allotopotype*, ♀. *Paratopotypes*, 1 ♂, 1 ♀, with types.

In its general appearance, the present fly is most similar to *Gnophomyia (Gnophomyia) lachrymosa* Alexander, differing conspicuously in the structure of the male hypopygium, especially the very long, slender outer dististyle, the basal tooth of the inner style, and the strongly narrowed apex of the phallosome. The halteres of *lachrymosa* are black throughout.

***Gnophomyia (Gnophomyia) perlata* sp. n.**

General coloration dull black; anterior pretergites conspicuously light yellow; halteres with knob clear light yellow; legs brown, the

terminal segments blackened; wings unusually broad, especially in male, the width (male) exceeding one-third the length; male hypopygium with the outer dististyle terminating in a straight black spine; inner dististyle with the basal lobe obtuse.

*Male*.—Length, about 5.3–5.6 mm.; wing, 6 x 2.0 to 6.2 x 2.2 mm.

*Female*.—Length, about 5.5 mm.; wing, 6.2 x 1.9 mm.

Rostrum and palpi black. Antennae black, relatively short; flagellar segments suboval to elongate, the longest verticils exceeding the segments. Head black, sparsely pruinose.

Thoracic notum dull black, the surface more or less pruinose; anterior pretergites conspicuously light yellow; humeral region of praescutum and extreme posterior portions of scutal lobes slightly reddened. Pleura dull black, the dorsopleural membrane a trifle brightened; meral region yellow. Halteres with stem obscure yellow, the knob clearer yellow. Legs with the fore and middle coxae blackened, their tips more or less paler, posterior coxae uniformly yellow; trochanters brownish yellow, the posterior pair clearer yellow; remainder of legs brown, the terminal segments more blackened. Wings unusually broad, especially in male, representing the maximum in this respect as found in the Neotropical fauna; membrane strongly suffused with brown but not as dark as in *flebilis*; prearcular field restrictedly more yellow; stigma very narrow, still darker brown; veins dark brown, those in the prearcular field brighter. Venation:  $Sc_1$  ending about opposite fork of  $R_{2+3+4}$ ,  $Sc_2$  far from its tip, about opposite the fork of  $Rs$ ;  $R_{2+3+4}$  moderately arcuated;  $Rs$  in direct longitudinal alignment with  $R_4$ , as common in the genus; cell 1st  $M_2$  widened distally; *m-cu* variable in position, from about one-half to nearly its entire length beyond the fork of  $M$ .

Abdomen, including the genitalia of both sexes, brownish black. Male hypopygium with the outer dististyle a rather strongly curved blackened rod, narrowed into a long straight black spine or spike, its tip acute or subacute. Inner dististyle with the basal lobe obtuse. Phallosome with the aedeagus slender, blackened, the truncated tip pale. Ovipositor with cerci of moderate length, narrowed outwardly, the tips obtuse, with setae distributed over the entire length, as common in the genus.

*Holotype*, ♂, Abitagua, altitude 1,100 meters, March 18, 1940 (Macintyre). *Allotopotype*, ♀, March 21, 1940. *Paratopotype*, 1 ♂, with the allotype.

*Gnophomyia* (*Gnophomyia*) *perlata* has the broadest wings of any of the now numerous species known from Tropical America. In other regards it is apparently closest to *G. (G.) flebilis* sp. n., which differs further in the much more strongly darkened wings and in the details of structure of the male hypopygium, especially the dististyles.

### Trentepohlia Bigot

#### Trentepohlia (Mongoma) errans sp. n.

Coloration of thorax uniformly pale yellow; abdomen with a narrow dark brown subterminal ring, the remaining tergites brownish yellow,

the sternites clear yellow; legs obscure yellow throughout; wings with a pale yellow tinge, the yellow veins poorly differentiated against the ground; four veins issuing from cell *1st M*<sub>2</sub>; cell *Cu* closed by the touching of veins *Cu*<sub>1</sub> and *1st A*.

*Male*.—Length, about 5 mm.; wing, 5 mm.

Rostrum yellow; palpi yellow, the terminal segment a little darker. Antennae with scape and pedicel yellow, flagellum a trifle darker, brownish yellow; flagellar segments oval with inconspicuous verticils. Head pale gray; anterior vertex reduced to a narrow strip.

Thorax almost uniformly pale yellow, the mesonotum a trifle more reddish; praescutum with scattered erect setae. Halteres pale yellow. Legs obscure yellow. Wings with a pale yellow tinge, the yellow veins poorly differentiated against the ground. Venation: *Sc*<sub>1</sub> ending just beyond fork of *Rs*, *Sc*<sub>2</sub> some distance from its tip, *Sc*<sub>1</sub> alone subequal to *R*<sub>2</sub>; *R*<sub>2</sub> about its own length before fork of *R*<sub>3+4</sub>, cell *R*<sub>3</sub> thus relatively short; four branches (*R*<sub>1</sub>, *M*<sub>1+2</sub>, *M*<sub>3</sub> and *M*<sub>4</sub>) issue from cell *1st M*<sub>2</sub>, the medial branches distinct but unusually pale and subevanescent; cell *Cu* closed by the apical touching of veins *Cu* and *1st A*; cell *2nd A* relatively large.

Abdominal tergites brownish yellow, sternites clear yellow; segment eight and part of nine dark brown to form a narrow subterminal ring; hypopygium yellow.

*Holotype*, ♂, Abitagua, altitude 1,100 meters, June 13, 1941 (Macintyre).

*Trentepohlia (Mongoma) errans* is the first member of the great subgenus *Mongoma* Westwood to be discovered in the New World. In the Palaetropical regions it is one of the largest and most characteristic groups in the Tipulidae. The present fly is certainly a member of the subgenus and its discovery in Tropical America is of unusual interest. Superficially the fly resembles certain species of the subgenus *Paramongoma* Brunetti, such as *T. (P.) pallida* (Williston).

## BOOK NOTICES

A MONOGRAPHIC STUDY OF THE NORTH AMERICAN SPECIES OF THE SUBFAMILY GYPONINAE (HOMOPTERA—CICADELLIDAE) EXCLUSIVE OF XEROPHLOEA, by DWIGHT M. DELONG. Graduate Studies, Contributions in Zoology and Entomology, No. 5, Biological Series. Published by THE OHIO STATE UNIVERSITY, Columbus 10, Ohio. 1943. Pp. xiv+116, 35 plates. 6¼ x 9 inches. Price, \$3.00.

For many years the homopterous family Jassidae remained one of the most neglected in the order and except for a few outstanding revisioned papers by Signoret, Spánberg, Ball, Osborn and Kirkaldy, only general faunistic works on the Homoptera as a whole, such as Melichar's Middle European and Ceylonese monographs, Distant's Fauna of British India and Fowler's Biologia Centrali-Americana, had been published prior to 1920. In the early twenties the late Professor C. F. Baker came to the conclusion that a complete revision of the group was essential before further work was possible. With the cooperation of a number of specialists and museum curators, he framed a new classification. The old Jassidae were raised to superfamily rank and split up into eighteen families, most of which were further divided into subfamilies and tribes. Naturally this

classification was purely tentative and was not meant for publication, but only as a basis on which the study of the superfamily could be developed. Professor Baker hoped that by international cooperation it would be possible eventually to place all the known genera within this framework and to modify it if necessary before publication. In 1923 he published prematurely an abbreviated form of this classification as a synopsis of families of Jassoidea (Baker, 1923, Philipp. Jour. Sci., 23(4): 351), in which he gave only fifteen families and no subfamily divisions. The families Eupelecidae, Euscelidae, Typhlocybidae and Eurymelidae were purposely omitted. Unfortunately Baker's early death brought his ambitious project to an unhappy end and the full classification has never been published. Since then, however, work on the superfamily has been greatly intensified and a very considerable amount of revisional work has been done and hundreds of new genera and species described, but we are still very far from achieving Baker's object, the proper major classification of the Jassoidea. Recently specialists such as Oman and Evans working independently have attempted some revision of the major categories. The latter, basing his classification on head structure, venation, and genitalia, has arrived at some surprising results which definitely modify Baker's tentative arrangement. But the majority of workers have been content to confine themselves to generic and specific revisions. Professor DeLong's book comes under this heading and he has done valuable work in this latest contribution to the onerous task of describing and classifying the enormous number of North American species belonging to this subfamily. The Gyponinae are particularly difficult to deal with, comprising as they do so many superficially similar species. Professor DeLong, however, was able to study a great many of the type specimens, in particular those of Spångberg's species from the Stockholm Museum, and to clear up many doubtful points.

The book is arranged in the usual manner, the introduction with acknowledgments being followed by general information on the family and on the distribution and occurrence of the species. Then comes a key to the genera dealt with in the monograph. Each genus is taken in turn, described, and a key to the species is given, followed by a short description of each included species. Altogether 13 genera and 170 species are described, of which 6 genera, 90 species and 7 varieties are new to science. There is a short bibliography followed by 35 plates comprising over 600 good line figures illustrating the characters used in the monograph.

In a work of this kind it is not possible to be other than brief in the treatment of the subject since the primary object is to get on with the description and classification of the legion of unknown forms with which we are surrounded. Nevertheless we regret that Professor DeLong has said practically nothing of the position of the Gyponinae in the major classification of the superfamily Jassoidea nor of what has happened to the genus *Zinneca* A. & S., 1843, which Van Duzee includes in the Gyponinae in his Catalogue of North American Hemiptera. He apparently follows Van Duzee (1919) in placing *Penthimia* Germar in the Gyponinae but Baker (1923) regarded the Penthimiidae and Gyponidae as distinct families. Recently Evans (Psyche, 48: 113; 1941) regards these two families as distinct subfamilies of the Bythoscopidae, and there is certainly greater difference between *Penthimia* and the other gyponine genera dealt with by DeLong than there is between the other gyponine genera themselves. The North American genus *Zinneca* A. & S. listed by Van Duzee is synonymous with *Idiocerus* Lewis 1836, formerly placed in the *Bythoscopidae* and erroneously transferred by Oman to the *Eurymelidae* but now the type of a new family, the *Idioceridae* of Evans.

—W. E. CHINA, British Museum.

THE PHYLLOPHAGA OR MAY BEETLES OF GEORGIA, by P. W. FATTIG.  
Emory Univ. Mus. Bull. No. 2; 32 pages. Published by Emory University,  
Emory University, Ga.

Professor Fattig is located in one of the richest faunal areas in North America, that of the Southern Appalachian Mountains. The botanist Asa Gray of Harvard pointed this area out many years ago. It has more species of plants than any similar area north of Mexico. Seventy species of Phyllophaga are listed with details of distribution, host plants when known and the present location of specimens of rarities.—C. H. K.

✓ INSECTS AND OTHER PESTS ATTACKING AGRICULTURAL CROPS, by E. O. ESSIG and W. M. HOSKINS. California Agr. Extension Service, Circular 87 (Sept., 1934) revised Jan., 1944. 197 pages, 182 figs. Published by the College of Agriculture, University of California, Berkeley, Calif. Unbound.

Some California Chamber of Commerce must have had its collective backs turned when this volume came off the press. It is "inside information" for the California farmer and fruit grower. The many illustrations are excellent and its quality can be gauged by the names of the well-known entomologists who helped with the work. These are listed: H. J. Quayle, G. F. MacLeod, R. H. Smith, J. E. Eckert, S. F. Bailey, A. D. Borden, L. M. Smith, A. E. Michelbacher, G. L. Smith, E. G. Linsley, W. H. Lange, E. M. Stafford and R. L. Usinger.—C. H. K.

CATALOGUE OF THE REDUVIIDAE OF CHINA, by WILLIAM E. HOFFMAN. Lingnan University Sci. Bull. 10, pages iv and 80. 1944. Published by Lingnan University, Canton, China. Printed by the George Banta Publishing Co., Menasha, Wis. Price \$0.75.

"The final manuscript for this bulletin was prepared under difficulty, in a Japanese internment camp, and sent by 'underground' and air mail to the United States where my brother kindly undertook to see it through the press." \* \* \* "The work of identification was carried out at the British Museum and the United States National Museum in 1940. \* \* \* The present index to the literature should facilitate further study of the family in China and neighboring countries."

Under each species name is given a complete synonymy, each reference with locality of capture and journal of publication, then two paragraphs of "new" localities from the collection at Lingnan University, the British Museum, and a paragraph on extent of distribution.—C. H. K.

REVISION OF THE NORTH AMERICAN GENERA OF THE PHALAENID SUBFAMILY PLUSIINAE (LEPIDOPTERA), by J. McDUNNOUGH. Memoirs of the Southern California Academy of Sciences, Vol. 2, No. 2, pp. 175-232, Pl. I-V, May 1, 1944. Price \$1.50.

The brief introduction to this revision states no specific purpose other than a long-needed critical study of the group, and no outline of procedure other than brief mention of a careful study of structural characters. Lepidopterists who have been familiar with the author's work on the order will take his name as a guarantee of care and thoroughness in the study; some of them, including the reviewer, may wish that the published results might have included more than a treatment of the genitalia.

Since genitalic structures may be, and in this group apparently are adequate for the separation of even closely related species, the revision will be a great help to taxonomists, the more so because of the inclusion of descriptions and figures of female genitalia as well as male. At the existing stage of our knowledge of North American Lepidoptera the reviewer continues to regard a revision as a good opportunity for more extensive treatment embracing a reasonable thorough survey of all knowledge of the included material. Ecological facts are often meager, hence this ideal is little more than a desire for the evaluation of all characters in place of the heavy emphasis on genitalia that the last thirty years have witnessed. Entomologists can hardly enjoy the same discriminating appreciation of these organs that the insects themselves must have, but are more likely to see wings and other appendages and to attempt identification by these more obvious structures and by color and pattern.

During the war we must recognize handicaps in publication. Perhaps in normal years it would be more reasonable to express a wish for figures of the insects, even though their delineation elsewhere may be entirely adequate for those who have the necessary publications.

In short, while the study does not attain the reviewer's ideal of a revisional article, it is an excellent and scholarly evaluation of the group based primarily on genitalia, and as such will be another assurance of Dr. McDunnough's high place among North American lepidopterists.—A. W. L.

# THE ENTOMOLOGICAL SOCIETY OF AMERICA

## LIST OF MEMBERS

(MARCH, 1944)

In this list, which is arranged alphabetically, members are given in lower case type, Fellows in small caps and Honorary Fellows in capitals. The year of admission to membership is given before the name, and of election to Fellowship and Honorary Fellowship in parentheses following the address. Names of Life Members are indicated by asterisk (\*) and the special field of work in italics. Ch. indicates Charter Member, 1906.

- '39. Aamodt, T. L., State Entomologist's Office, University Farm, St. Paul, Minn.
- '39. Ackermann, Otto, 639 Walnut St., Irwin, Pa. *Lepidoptera*.
- '27. ADAMS, C. F., State Board of Health, Jefferson City, Mo. (F. '29). *Diptera*.
- '40. Ahrens, Carsten, Fifth Avenue High School, Pittsburgh, Pa. *Odonata*.
- '10. ALEXANDER, CHARLES P., Massachusetts State College, Amherst, Mass. (F. '20). *Tipulidae*.
- '33. Alexander, E. Gordon, Dept. of Biology, Univ. of Colorado, Boulder, Colo. *Orthoptera*.
- '13. ALLEE, W. C., Zool. Bldg., Univ. Chicago, Chicago, Ill. (F. '39). *Behavior*.
- '25. ALLEN, H. W., Box 150, Moorestown, New Jersey, (F. '40). *Tachinidae*, *Tiphiidae*.
- '42. Allen, Theodore, 2520 Mulberry Avenue, Muscatine, Iowa.
- '32. Amos, John M., 204 Agri. Education Bldg., Penn. State College, State College, Pennsylvania. *Coccidae*, *Cerambycidae*.
- '30. Anderson, Edwin J., Frear Laboratory, State College, Pa. *Beekeeping*.
- '29. Anderson, Lauren D., Virginia Truck Experiment Station, P. O. Box 2160, Norfolk 1, Va. *Gerridae*.
- '37. Anderson, William H., Rm. 429, U. S. National Museum, Washington, D. C. *Coleopterous larvae*.
- '39. Andre, Floyd, Office of Experiment Stations, U. S. D. A., Washington, D. C. *Thysanoptera*.
- '37. Anduze, Pablo J., Instituto Nacional de Higiene, Ministerio de Sanidad y Asistencia Social, Caracas, Venezuela. *Culicidae*.
- '32. ANNAND, P. N., Bureau of Entomology and Pl. Quar., Washington, D. C. (F. '39). *Aphids*.
- '28. App, Bernard A., Box 316, Burgow, N. C. *Economic Entomology*.
- '40. Archer, 2nd Lt. Allan F., Surgeon's Office, Camp Hdqts., Camp Van Dorn, Mississippi. *Arachnida*.
- '23. Armstrong, T., Ent. Lab., Vineland Station, Ontario, Canada. *Scarabaeidae*.
- '36. Ashton, Donald F., 2711 Van Dyke Ave., Raleigh, N. C. *Culicidae*.
- '37. Assmuth, Rev. Joseph, Fordham University, New York, N. Y. *Isoptera*.
- '42. Atkins, Edward L., Jr., Route 1, Smithshire, Illinois.
- '34. Au, Sung Hin, P. O. Box 3319, Honolulu, Hawaii. *Aphids*.
- '29. Audant, Andre, S. N. P. A., Port-au-Prince, Haiti. *Chrysomelidae*.
- '33. AVINOFF, A., Carnegie Museum, Pittsburgh 13, Pa. (F. '39). *Lepidoptera*.

## B

- '37. Babers, Lt. Col. Frank H., 58 A.A.A. Brigade, Fort Bliss, Texas. *Physiology*.
- Ch. \*BACK, E. A., Bur. Ent. and Pl. Quar., Washington, D. C. (F. '38). *Asilidae*, *Aleyrodidae*.
- '39. Badertscher, A. Edison, 103 Bonnie Hill Road, Burnbrae Towson, Md. *Insecticides*.



- '21. BAERG, W. J., Univ. Arkansas, Fayetteville, Ark. (F. '32). *Poisonous Arthropods*.
- '30. \*Bailey, J. W., 27 Willway Road, Richmond, Va. *Myriapoda*.
- '11. BAKER, A. C., Laboratorio Entomologico, Calzada Tacuba 295, Colonia Anahuac, Mexico, D. F., Mex. (F. '29). *Aphididae, Aleyrodidae*.
- '43. Baker, Edward W., Laboratorio Entomologico, Apartado 3, Colonia Anahuac, D. F., Mexico.
- '22. Baker, Howard, 5201 Oakland Ave., St. Louis, 10, Mo. *Apple and Pecan Insects*.
- '36. Baker, Walter C., Health Center Bldg., Corpus Christi, Texas. *Toxicology*.
- '28. Balch, R. E., Dom. Ent. Lab., Fredericton, New Brunswick, Canada. *Forest Insects*.
- '20. BALDUF, W. V., 308 Entomology Bldg., Univ. of Illinois, Urbana, Ill. (F. '40). *Entomophagous insects*.
- '43. Balock, John W., Laboratorio Entomologico, Apartado 3, Colonia Anahuac, D. F., Mexico.
- '38. Ballou, Charles H., Estacion Experimental de Agricultura y Zootecnia, El Valle, Distrito Federal, Venezuela. *Economic Entomology*.
- '08. BANKS, NATHAN, Mus. Comp. Zool., Harvard Univ., Cambridge, Mass. (F. '14).
- '37. Barber, George W., 274 Dwight St., New Haven, Conn. *Corn earworm*.
- Ch. BARBER, H. G., 143 E. Third Ave., Roselle, N. J. (F. '30). *Hemiptera*.
- Ch. BARBER, H. S., U. S. National Museum, Washington, D. C. (F. '28). *Coleoptera*.
- '23. Bare, Clarence O., Box 7062, Richmond 21, Va. *Notonectidae*.
- Ch. Barlow, John, State College, Kingston, Rhode Island. *Corrodentia*.
- '26. BARNES, J. F., Rothamsted Exp. Sta., Harpenden, Herts, England. (F. '37). *Cecidomyiidae*.
- '28. Barnes, O. L., 1104 Ash Ave., Tempe, Arizona. *Hemileuca, Anastaxus*.
- '43. Barnes, Ralph C., U. S. Public Health Service, 15 Pine St., New York 5, N. Y.
- '40. Barnett, 2nd Lt. Herbert C., Sn. C., 10418-106th St., Ozone Park, Long Island, N. Y.
- '39. Barrett, John P., care of Armour and Co., Chemical Research Dept., Union Stock Yards, Chicago 9, Ill. *Calliphoridae*.
- '41. Barrett, Lt. Paul H., Station Hospital, Camp Adair, Ore. *Aquatic Insects*.
- '35. Barrett, W. L., Jr., Box 509, Uvalde, Texas. *Diptera*.
- '39. Bartlett, Lawrence M., Old Court House Annex, care of Farm Bureau, Mineola, N. Y. *Ephemeroptera*.
- '18. BASINGER, A. J., Citrus Exp. Sta., Riverside, Calif. (F. '41). *Calliphoridae*.
- '31. BAILES, MARSTON, The Rockefeller Foundation, Apartado 2508, Bogota, Colombia, (F. '40). *Diptera, Trypetidae*.
- '24. BEAMER, RAYMOND H., 1000 Missouri St., Lawrence, Kansas. (F. '34). *Homoptera, Cicadellidae*.
- '34. Beck, Elmer W., 626 Virginia Ave., Toledo 10, Ohio. *Parasites European Corn Borer*.
- '29. Bedard, W. Dells, 335 Giannini Hall, Univ. California, Berkeley, Calif. *Scolytidae, Braconidae*.
- '20. Bedford, Hugh W., Gov't Ent., Agri. Research Serv., Ent. Sect., Wad Medani, Sudan, Africa.
- '43. Beebe, Wm., New York Zoological Society, Zoological Park, Bronx Park, New York, N. Y.
- '42. Belkin, 1st Lt. John N., 18th Malaria Survey Unit, NOPE Staging Area, New Orleans, La.
- '25. BELL, ERNEST, 150-17 Roosevelt Ave., Flushing, N. Y. (F. '40). *Hesperiidae*.
- '40. Benesh, Bernard, P. O. Box 159, North Chicago, Ill. *Lucanidae*.
- Ch. Bentley, G. M., 64 Biology Bldg., Univ. Tenn., Knoxville 16, Tenn. *Orthoptera*.
- '23. Benton, Curtis, 1216 Ball St., Lafayette, Indiana.
- '17. \*BEQUAERT, JOSEPH C., Harvard Med. Sch., Boston, Mass. (F. '34). *Vespididae, Tabanidae*.
- '28. Berley, J. A., Div. Ent., Clemson College, So. Carolina. *Coccidae, Odonata*.
- '43. Berner, Major Lewis, 0461681, Hq. Africa Middle-East Wing, A. T. C., A. P. O. 625, care of Postmaster, Miami, Florida.

- '39. Berry, Paul A., Blanca del Tabare 2980, Montevideo, Uruguay. *Biological Control*.
- '34. Bess, Henry A., 56 Hillhouse Ave., New Haven, Conn. *Ecology*.
- Ch. BETTEN, CORNELIUS, 104 Corson Place, Ithaca, New York. (F. '37). *Trichoptera*.
- '28. Bibby, Ch. P. M., F. F., U. S. Naval Hospital, Pensacola, Fla. *Cicadidae*.
- '38. \*Bickley, Wm. E., Jr., U. S. Public Health Service, 300 Essex Bldg., Norfolk 10, Va. *Chrysopidae*.
- '25. Bigger, J. H., Room 129, Natural Resources Bldg., Nat. History Survey, Urbana, Ill. *Plant Resistance to Insect Attack*.
- '30. Billings, Samuel C., 8407 Woodcliff Court, Silver Spring, Md. *Mothproofing*.
- '13. BILSING, S. W., College Station, Texas. (F. '41). *Cerambycidae*.
- Ch. BIRD, HENRY, 600 Milton Road, Rye, N. Y. (F. '30). *Noctuidae, Papaipema*.
- Ch. BISHOPP, F. C., Bur. Ent. & Pl. Quar., Washington, D. C. (F. '28). *Ixodoidea, Siphonaptera, Anoplura*.
- '24. BISHOPP, SHERMAN C., Dept. Biol., University Rochester, Rochester, N. Y. (F. '43). *Arachnida*.
- '25. Bissell, Theo. L., Experiment, Georgia. *Aphididae, Curculionidae*.
- '37. Blackburn, Norris D., Ohio Agri. Exp. Station, Wooster, Ohio. *Chrysomelidae*.
- Ch. BLAISDELL, F. E., Sr., California Academy of Sciences, Golden Gate Park, San Francisco, Calif. (F. '24). *Tenebrionidae, Melyridae*.
- '28. Blanchard, R. A., Box 32, Urbana, Illinois. *Plant resistance to insect attack*.
- '32. Blanton, Franklin S., P. O. Box 786, Babylon, L. I., N. Y. *Trypetidae, Otitidae*.
- '30. Blauvelt, Helen Hayden, care of Wm. Savey, Lake Rd., Ithaca, N. Y.
- '28. Blauvelt, Wm. E., Comstock Hall, Cornell Univ., Ithaca, N. Y.
- '37. Bleasdale, Gale Gates, Tipton, Iowa. *Rynchophora*.
- '29. BOESEL, M. W., R. R. No. 2, Oxford, Ohio. (F. '43). *Chironomidae*.
- '37. Bohart, Richard M., Div. of Ent., Univ. Calif., 405 Hilgard Ave., Los Angeles, Calif. *Strepsiptera, Hymenoptera*.
- '28. BORROR, DONALD J., Dept. of Zool. and Ent., Ohio State Univ., Columbus, Ohio. (F. '43). *Odonata*.
- '14. BOVING, ADAM G., U. S. Nat. Museum, Washington, D. C. (F. '29, H. F. '41). *Coleopterous larvae*.
- '42. Bowery, Thomas G., 214 Birmingham Ave., Avalon, Pgh. 2, Pa.
- '33. Boyce, A. M., Citrus Exp. Sta., Riverside, Calif.
- Ch. BRADLEY, J. C., Cornell Univ., Ithaca, N. Y. (F. '14). *Campsomeris, Vespididae, Scolitidae*.
- '19. BRADLEY, G. H., Box 654, New Smyrna Beach, Fla. (F. '41) *Diptera, Culicidae*.
- '37. Bradley, Wm. G., Box 576 M. O., Toledo, Ohio. *Parasitic Hymenoptera*.
- '23. Branch, Hazel E., Univ. of Wichita, Wichita, Kansas. *Chironomidae larvae*.
- '25. Brandhorst, Carl T., 106 Lincoln St., Seward, Nebraska. *Wasps*.
- Ch. BRAUN, ANNETTE F., 2702 May St., Cincinnati 6, Ohio. (F. '24). *Microlepidoptera*.
- '26. BREAKEY, E. P., Western Washington Exp. Sta., Puyallup, Wash. (F. '43). *Cicadellidae*.
- '37. Breland, Osmond P., Dept. Zoology, University of Texas, Austin, Texas. *Chalcidoidea*.
- '29. Brindley, T. A., Box 73, Moscow, Idaho. *Pea Weevil*.
- '26. BRITAIN, W. H., McDonald College P. O., Quebec, Canada (F. '37). *Homoptera*.
- '20. BROMLEY, STANLEY W., High Ridge Road, Stamford, Connecticut. (F. '37). *Asilidae*.
- '40. Brookman, Bernard, 1728 N. W. 32nd Ave., Portland 10, Oregon. *Diptera*.
- '41. Brooks, Ivan C., Dept. of Entomology, Purdue Univ., Lafayette, Indiana. *Diptera*.
- '39. Brower, Auburn E., 5 Hospital St., Augusta, Maine. *Lepidoptera, Catocala*.
- '33. Brown, F. Martin, Fountain Valley School, Colorado Springs, Colo. *Pieridae of the Americas*.
- '42. Brown, John H., University of Alberta, Edmonton, Alberta, Canada.

- '26. BROWN, W. J., Ent. Branch, Dept. Agri., Ottawa, Canada. (F. '40). *Coleoptera*.
- Ch. BRUES, C. T., Biological Laboratory, Harvard University, Cambridge, Mass. (F. '14). *Hymenoptera*.
- '30. BRUNER, S. C., Estacion Agronomica, Santiago de las Vegas, Havana, Cuba. (F. '37). *Homoptera, Hemiptera of Cuba*.
- '33. BRYANT, ELIZABETH B., Mus. Comp. Zool., Cambridge, Mass. (F. '43). *Arachnida*.
- '30. Bryant, Owen, Steamboat Springs, Colo. *Coccinellidae*.
- '38. Bryce, P. I., Entomological Lab., Vineland Station, Ontario, Canada. *Fruit Tree Insects*.
- '27. Buckell, E. R., Field Crop Insect Laboratory, P. O. Bldg., Kamloops, Brit. Col., Canada. *Orthoptera, Odonata*.
- Ch. \*BUENO, J. R. DE LA TORRE, 311 E. 4th St., Tucson, Ariz. (F. '28). *Aquatic Hemiptera, Heteroptera*.
- '31. Bugbee, Robert E., Dept. Zoology, Indiana University, Bloomington, Ind. *Eurytomidae*.
- '38. Bunn, Maj. Ralph W., 1st Med. General Lab., A. P. O. 519, care of Postmaster, New York, N. Y. *Fulgoridae, Curculionidae*.
- Ch. BURGESS, A. F., 20 Sanderson St., Greenfield, Mass. (F. '17). *Carabidae*.
- '35. Burks, Capt. B. D., Nat. History Survey, Rm. 231, Natural Resources Bldg., Urbana, Ill. *Chalcididae*.
- '27. \*Burrell, R. W., care of Mrs. L. E. Burrell, P. O. Box 1049, Orlando, Fla. *Thynnidae, Tiphidae*.
- '29. Bushey, Clinton J., Olivet Nazarene College, Kankakee, Ill. *Curculio*.
- '33. Bushnell, Ralph J., Univ. of Connecticut, Storrs, Conn. *Conopidae*.
- '35. Bussart, J. Everett, 425 East Illinois St., Wheaton, Ill. *Tachinid Biology*.
- '30. BUTT, F. H., Cornell Univ., Ithaca, N. Y. (F. '40).
- '20. Buys, John L., Dept. Biol., St. Lawrence Univ., Canton, N. Y. *Homoptera, Cicadellidae*.
- '36. Buzicky, Capt. Albert W., 512 Montrose Lane, St. Paul, Minn. *Chyphotes*.
- '24. BYERS, C. FRANCIS, Dept. Biol., Univ. Fla., Gainesville, Fla. (F. '41). *Odonata*.
- '25. Caffrey, D. J., Bur. Ent. & Pl. Quar., Washington 25, D. C.
- '35. \*Caldwell, John S., 535 So. Court St., Circleville, Ohio. *Fulgoridae, Psyllidae*.
- '43. Callan, E. McC., Imperial College of Tropical Agri., Trinidad, B. W. I.
- Ch. CALVERT, PHILIP P., P. O. Box 14, Cheyney, Pa. (F. '07, H. F. '39). *Odonata*.
- '28. CAMPBELL, FRANK LESLIE, Am. Assoc. Advancement Science, Smithsonian Inst. Bldg., Washington 25, D. C. (F. '34). *Toxicology*.
- '13. CAMPBELL, ROY E., 1208 E. Main, Alhambra, California. (F. '41).
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- '40. Capps, Hahn W., Div. of Insect Identification, U. S. Nat. Mus., Washington, D. C. *Geometridae*.
- '33. CARPENTER, F. M., Mus. Comp. Zool., Harvard Univ., Cambridge, Mass. (F. '38). *Mecoptera, Neuroptera*.
- '26. Carpentier, Fritz, Inst. Ed. Van Veneden, 10 Rue Vivegnis, Leige, Belgium. *Morphology*.
- '31. Carruth, Laurence A., Div. of Entomology, New York Agri. Exp. Station, Geneva, N. Y. *Meloidae*.
- '22. CARTER, WALTER, P. O. Box 3166, Honolulu, T. H. (F. '38). *Insect Transmission of Plant Diseases*.
- '26. CARTWRIGHT, O. L., Agri. Exp. Station, Clemson, S. C. (F. '41). *Scarabaeidae*.
- '26. Cartwright, William B., Box 495, Lafayette, Indiana. *Hessian Fly*.
- '29. Cendana, S. M., Agricultural College, Laguna, P. I. *Coccinellidae*.
- '41. Chamberlain, Roy W., Dept. of Entomology, Montana State College. Bozeman, Mont. *Collembola*.
- '22. CHAMBERLAIN, JOSEPH C., P. O. Box 278, Forest Grove, Oregon. (F. '38). *Chelonethida*.
- Ch. CHAMBERLAIN, R. V., Univ. Utah, Salt Lake City, Utah. (F. '17). *Myriapoda, Arachnida*.

- '18. Chambers, Ernest L., Rm. 424 Northeast, State Capitol, Madison, Wisc.  
 '14. Champion, H. G., Dept. of Forestry, Imperial Forestry Inst., Univ. Oxford, Oxford, England. *Coleoptera*.  
 '15. Chapman, James W., Silliman Inst., Dumaguete, Philippine Is. *Ants of P. I.*  
 '41. Chickering, A. M., 206 So. Mingo St., Albion, Michigan. *Arachnida*.  
 '13. Childs, Leroy, Hood River, Oregon. *Apple and Pear Insects*.  
 '30. Christenson, L. D., Bur. of Ent. & P. Q., 1583 D. St., San Bernardino, Calif. *Aptera, Myriapoda*.  
 '27. Clagg, C. F., Barnstable, Mass. *Mecoptera, Hemiptera*.  
 '22. Clark, Chas. A., Box 576, Toledo, Ohio. *Odonata, Ichneumonidae*.  
 '34. Clarke-Macintyre, William, 142 Prospect St., East Orange, N. J. *Rhopo-locera of Ecuador*.  
 '14. CLAUSEN, CURTIS P., Bur. Entomology & P. Q., Washington, D. C. (F. '37). *Insect Parasites*.  
 '42. Cobb, William R., 1624 Rincon Dr., Whittier, Calif.  
 '07. COCKERELL, T. D. A., 908 Tenth St., Boulder, Colo. (F. '08, H. F. '37). *Bees, Fossil Insects*.  
 '39. COLCORD, MABEL, 2520 Fourteenth St., N. W., Washington, D. C. (F. '43). *Bibliography*.  
 '28. COLE, 2ND LT. ARTHUR C., JR., O-577167, A. P. O. 12218-B, care of postmaster, New York, N. Y. (F. '43). *Formicidae*.  
 '16. COLE, F. R., P. O. Box No. 6, Redlands, Calif. (F. '38). *Diptera, Hymenoptera*.  
 '16. Collins, C. W., Bureau of Ent. & Plant Quar., 8 Whippany Road, Morristown, N. J. *Insect Vectors of Dutch Elm Disease*.  
 '29. Collins, Donald L., 3645 N. 15th St., Philadelphia 40, Pa. *Coleoptera*.  
 '21. Compton, Chas. C., Nat. History Survey, Room 127, Nat. Resources Bldg., Urbana, Illinois. *Greenhouse and Truck Insects*.  
 '29. Conklin, J. G., Dept. Ent., Univ. N. H., Durham, N. Hampshire. *Coccinellidae*.  
 '35. Connell, 1st Lt. Walter A., West Grove, Pa. *Diptera*.  
 '41. Cook, Margaret L., 726 E. Adams Blvd., Los Angeles 11, Calif. *Sphecoidea, Vespoidea*.  
 Ch. Cook, Mel T., 255 Barnard Road, Larchmont, N. Y. *Entomogenous Fungi*.  
 '19. COOK, WM. C., 219 Newell St., Walla Walla, Wash. (F. '38). *Noctuidae*.  
 '10. COOLEY, R. A., U. S. Public Health Service, Hamilton, Mont. (F. '24). *Ixodidae, Ixodiphaginae*.  
 '36. Cooper, James Furman, Univ. Exs. Farm, Kearneysville, W. Va. *Pear Psylla*.  
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 '39. Cope, Lt. Oliver B., Malariology Unit No. 64, care of Fleet Post Office, San Francisco, Calif. *Anoplura, Mallophaga, Diptera Pupipara*.  
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 '32. Cory, Ernest N., State Entomologist, College Park, Maryland.  
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 '15. COTTON, RICHARD T., 343 No. 14th St., Manhattan, Kans. (F. '37). *Curculionid larvae*.  
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 '38. Crowell, H. H., Box 802, Ancon, Canal Zone. *Physiology*.  
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## D

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- '42. Dailey, Ervin F., 825 East 78th St., Seattle, Wash. *Myriapoda*.
- '42. Dalmot, Herbert T., Dept. Ent., Cornell Univ., Ithaca, N. Y.
- '43. Dambach, Charles A., Dept. of Zool. and Ent., Ohio State Univ., Columbus 10, Ohio.
- '25. DARLINGTON, P. J., JR., Mus. Comp. Zool., Cambridge, Mass. (F. '38). *Adephaga, Dryopidae*.
- '30. DAVIDSON, RALPH H., Dept. Ent., Ohio St. Univ., Columbus 10, Ohio. (F. '43). *Cicadellidae*.
- '43. Davidson, Thomas R., Dept. of Ent., Univ. of Alberta, Edmonton, Alberta, Can.
- '22. Davis, E. W., Box 218, Union Gap, Washington. *Cicadellidae*.
- Ch. DAVIS, J. J., Purdue Univ., Lafayette, Ind. (F. '17). *Aphididae, Lachnosterna*.
- Ch. \*DAVIS, WM. T., 146 Stuyvesant Place, Staten Island, N. Y. (F. '17, H. F. '43). *Cicadidae, Orthoptera*.
- '13. DEAN, GEO. A., K. S. C., Manhattan, Kansas. (F. '17). *Economic Entomology*.
- '33. Dean, R. W., Cottage Road, Poughkeepsie, N. Y. *Rhynchophora*.
- '36. Dearolf, Kenneth, Public Library Museum, Dayton, Ohio. *Cave Insects*.
- '25. Deay, Howard O., Dept. Ent., Purdue Univ., Lafayette, Ind. *Coreidae, Tenagobia, Micronecla*.
- '38. DeBach, Paul H., 309 C St., Marysville, California. *Chalcidoidea*.
- '24. Decker, Geo. C., Nat. Hist. Survey, Natural Resources Bldg., Urbana, Ill. *Stalk Borers, Crambus*.
- '24. DeCoursey, R. M., Conn. Agri. College, Storrs, Conn. *Hemiptera*.
- '29. DeLeon, Donald, Box 217, Lafayette, California. *Scolytidae*.
- '14. DELONG, D. M., Dept. Ent., Ohio State Univ., Columbus, Ohio. (F. '30). *Cicadellidae*.
- '36. Del Ponte, Edward, Instituto Bacteriologica, Calle Velez Sarsfield 563, Dept. Nac. de Hygiene, Buenos Ayres, Arg. *Parasitic Insects*.
- '31. Denis, J. R., Laboratoire de Zoologie, Faculte des Sciences, Univ. of Dijon, Dijon (Cote d'Or), France. *Apterygota*.
- '34. \*DENNING, DONALD G., U. S. Public Health Service, Quarantine Station, Miami Beach 39, Fla. (F. '43). *Trichoptera, Corethrinae*.
- '37. Dennis, Clyde A., Tusculum College, Greeneville, Tenn. *Formicidae*.
- '34. \*Deonier, C. C., Box 3391, Orlando, Fla. *Muscidae*.
- '27. Dicke, Ferdinand F., Box 576 M. O., Toledo, Ohio. *Harmolita Parasites*.
- '39. Dickson, Robert C., Dept. Ent., Citrus Exp. Sta., Riverside, Calif. *Aphididae*.
- '22. DIETRICH, HENRY, Comstock Hall, Cornell Univ., Ithaca, N. Y. (F. '43). *Coleoptera*.
- '35. Dillon, Lawrence Samuel, 425 Oak Terrace, West Reading, Pa. *Cerambycidae*.
- '24. Dills, L. E., Dept. Zool. & Ent., Penn. State College, State College, Pa.
- '26. Dirks, C. O., 32 Coburn Hall, Univ. of Maine, Orono, Maine. *Biology of Lepidoptera*.
- '31. Ditman, L. P., Univ. Maryland, College Park, Maryland. *Ecology*.
- '27. \*Doak, K. D., 2517 So. Fairfax, Alexandria, Va. *Gelechiidae*.
- '36. \*Dodge, Harold R., Box 1095, Macon, Ga. *Scolytidae*.
- '22. DOERING, KATHLEEN C., Dept. Ent., Univ. Kansas, Lawrence, Kans. (F. '35). *Cercopidae, Fulgoridae*.
- '41. Dorsey, Carl K., Camp Peary (Hospital), Williamsburg, Va. *Immature Coleoptera*.
- '37. Dorst, Major Howard E., 1535½ Parkway Ave., Salt Lake City, Utah. *Cicadellidae*.
- '22. Doucette, Chas. F., Box 458, Sumner, Washington. *Ornamental Insects*.
- '23. Douglass, J. R., Box 1100, Twin Falls, Idaho.
- '28. DOVE, W. E., Box 3391, Orlando, Fla. (F. '40). *Animal Parasites*.
- '31. Dow, Lt. Richard, 30 Priscilla Road, Reading, Mass. *Sphécoid Wasps*.
- '22. Dowden, Philip B., 56 Hillhouse Ave., New Haven, Conn. *Parasitic Hymenoptera*.

- '22. DRAKE, CARL J., Iowa State College, Ames, Iowa. (F. '31). *Tingitidae*.  
 '37. Dreisbach, Robert R., 301 Helen St., Midland, Michigan. *Vespidae*.  
 '31. Driggers, Byrley F., Agri. Exp. Sta., New Brunswick, N. J. *Economic Entomology*.  
 '38. Drolet, Marcel, 95 Ste. Foy Road, Quebec, Quebec, Canada. *Cerambycidae*.  
 '26. Dunavan, David, 116 N. Clemson Ave., Clemson, South Carolina. *Haliplidae*.  
 '23. DUNCAN, CARL D., Box 4, Stanford Univ., Calif. (F. '41). *Vespidae, Bembicidae*.  
 '28. Dunnam, E. W., Box 8, Leland, Miss. *Cotton Resistance to Insects*.  
 '14. Dusham, E. H., 607 N. Burrowes St., State College, Pa. *Coleoptera*.  
 '43. Dybas, Henry S., Div. of Insects, Field Mus. Nat. Hist., Chicago, Ill.

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- Ch. Easton, Norman S., 458 High St., Fall River, Mass. *Coleoptera*  
 '31. ECKERT, J. E., University Farm, University of California, Davis, Calif. (F. '43). *Beekeeping*.  
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 '31. Elliott, D. C., Southwestern La. Institute, Lafayette, Louisiana. *Aphididae*.  
 '24. Elmore, J. C., 1208 E. Main, Alhambra, Calif. *Truck Crop Insects*.  
 '19. EMERSON, ALFRED E., Dept. Zool., Univ. Chicago, Chicago, Ill. (F. '37). *Isoptera, Termitophiles*.  
 '38. Emerson, Lt. K. C., Fort William McKinley, Rizal, P. I. *Mallophaga*.  
 '25. Enders, Howard E., 249 Littleton St., West Lafayette, Ind. *Mallophaga*.  
 '38. Epstein, Erwin J., 3264 Cedarbrook Road, Cleveland Heights, Ohio. *Odonata*.  
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 '18. EYER, JOHN R., State College, New Mexico. (F. '38). *Cicadellidae, Chermidae*.

## F

- '32. FAIRCHILD, GRAHAM BELL, Apartado 1252, Panama, Rep. of Panama. (F. '43). *Culicidae, Tabanidae*.  
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 '14. FERRIS, G. F., Natural History Museum, Stanford Univ., Calif. (F. '34). *Coccidae, Mallophaga, Anoplura, Diptera*.  
 '35. Field, William D., Bur. of Ent. & P. Q., Washington, D. C. *Arctidae, Lycaenidae*.  
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 '36. Fisk, Frank Wilbur, 1510 Twenty-first St., Washington, D. C. *Culicidae*.

- '30. FLANDERS, STANLEY E., Citrus Exp. Sta., Riverside, Calif. (F. '37). *Biology of Chalcidoidea*.
- '22. Fletcher, Frank C., Rm. 301, 100 Gibbs St., Rochester 1, N. Y. *Coleoptera*.
- '31. Fletcher, Fred W., Biochem. Dept., Dow Chemical Co., Midland, Michigan. *Insecticides*.
- '43. Flock, Robert A., P. O. Box 1297, Phoenix, Arizona.
- '24. FLUKE, C. L., King Hall, Univ. of Wisconsin, Madison 6, Wis. (F. '35). *Syrphidae*.
- '42. Fluno, John A., Quincy, Kansas.
- '38. Forbes, 2nd Lt. James, 2986 Marion Ave., New York 58, N. Y. *Formicidae*.
- '08. \*FORBES, WM. T. M., Cornell Univ., Ithaca, N. Y. (F. '30). *Lepidoptera, Neuropteroids*.
- '30. Foster, Charles E., Colgate Univ., Hamilton, N. Y. *Coccidae*.
- '20. \*Fournier, Mrs. Gaston, 90 Boul. Malesherbes, Paris 8, France. *Lepidoptera*.
- '11. FRACKER, S. B., Bureau of Ent. & Plant Quar., U. S. Dept. Agric., Washington, D. C. (F. '34). *Coreidae*.
- '23. FREEBORN, STANLEY B., 101 Giannini Hall, Univ. of Calif., Berkeley, Calif. (F. '38). *Culicidae*.
- '22. FRIEND, ROGER B., Agri. Exp. Sta., 153 Huntington St., New Haven, Conn. (F. '38). *Diptera*.
- '14. FRISON, T. H., Nat. History Survey, Natural Resources Bldg., Urbana, Ill. (F. '29). *Plecoptera and Bombidae*.
- '40. Froeschner, Richard C., 5102a Lotus Ave., St. Louis 13, Mo. *Hemiptera*.
- '40. Fronk, William D., 1820 Grant Ave., Ogden, Utah.
- Ch. Frost, C. A., 67 Henry St., Framingham, Mass. *Coleoptera*.
- '41. Frost, Florence M., 1376 Shattuck Ave., Berkeley 7, Calif. *Diptera*.
- '14. FROST, STUART W., 465 E. Foster Ave., State College, Pa. (F. '35). *Agromyzidae, Hispinae*.
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- '16. FULTON, B. B., State College, Raleigh, North Carolina. (F. '32). *Orthoptera*.
- '11. FUNKHOUSER, WM. D., Univ. Kentucky, Lexington, Ky. (F. '20). *Membracidae*.
- '40. Furniss, Robert L., 445 U. S. Court House, Portland, Oregon. *Forest Entomology*.

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- '16. GAIGE, F. M., Mus. Zool., Univ. Mich., Ann Arbor, Mich. (F. '38). *Formicidae*.
- Gardner, T. R., 25 Meadowbrook Rd., Chatham, N. J. *Parasites*.
- Garlick, W. G. P., Vineland Station, Ontario, Canada. *Tenthredinoidea*.
- ARMAN, PHILIP, Agri. Exp. Sta., New Haven, Conn. (F. '38). *Odonata, Acarina*.
- '39. Gauthier, Georges, Entomologiste, Ministere de l'Agriculture, Quebec, Quebec, Canada.
- '16. Gentner, Louis G., 22 Groveland Ave., Medford, Oregon. *Halticinae*.
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- '22. Gerry, Bertram I., Box 28, Wellesley Hills, Mass. *Culicidae and Chironomidae*.
- '32. GERTSCH, WILLIS J., Am. Mus. Nat. Hist., 77th St. & Central Park W., N. Y., N. Y. (F. '40). *Arachnida*.
- Ch. GIBSON, ARTHUR, Apt. 6, 30 Cooper St., Ottawa, Ontario, Canada. (F. '17).
- '14. Gibson, E. H., Trinity Episcopal Church, Galveston, Texas. *Hemiptera*.
- '41. Gillogly, Lorin R., 7020 St. Estaban St., Tujunga, California. *Niliidulidae*.
- '21. Gilmer, Paul M., Coastal Plains Experiment Station, Tifton, Georgia. *Cotton Insects*.
- '16. GLASER, R. W., Rockefeller Med. Res. Inst., Princeton, N. J. (F. '41). *Insect Diseases*.
- '11. Glasgow, Hugh, Experiment Station, Geneva, New York.
- '11. Glasgow, Robert D., State Education Bldg., Albany, N. Y. *Forest Insects*.

- '38. Gleissner, Bruce D., 20 Ridge Road, Cos Cob, Conn. *Insect Physiology*.  
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 '36. Gouck, Harry K., 6 Palm Ave., Savannah, Ga. *Plecoptera*.  
 '31. Gould, Geo. E., Purdue Univ., Lafayette, Indiana. *Rhagoletia, Semiaquatic Hemiptera*.  
 '39. Graham, Ensign Lewis T., care of Commander 3rd Fleet, Fleet P. O., San Francisco, Calif. *Membracidae*.  
 '17. GRAHAM, SAMUEL A., Univ. of Mich., Ann Arbor, Mich. (F. '32). *Forest Insects*.  
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## H

- '25. Haber, Vernon R., 355 West Ridge Ave., State College, Pa. *Orthoptera*.  
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 '23. Hadley, C. H., Bur. Ent. & Pl. Quar., Moorestown, N. J. *Japanese Beetle*.  
 '24. HAUSSLER, GILBERT J., Bur. Ent. & P. Q., Washington 25, D. C. (F. '41). *Ichneumonidae, Braconidae*.  
 '14. HAGAN, HAROLD R., Dept. Biology, College of the City of New York, 139th & Convent Ave., New York 31, N. Y. (F. '38). *Embryology*.  
 '25. HALL, DAVID G., Carlisle Barracks, Carlisle, Pa. (F. '41). *Sarcophagidae, Diptera*.  
 '41. Hambleton, Edson J., Office of Foreign Agri. Relations, U. S. D. A., Washington 25, D. C. *Tingitidae (Neotropical)*.  
 '14. Hamilton, Clyde C., Apt. 686, 3450 39th St. N. W., Washington 16, D. C.  
 '22. Hamner, A. L., Box 223, State College, Miss. *Aphidiidae, Phylloxera*.  
 '37. Handford, Richard H., Box 250, Brandon, Manitoba, Canada. *Acridae*.  
 '39. Hanson, John F., 167 Lowell Ave., Newtonville, Mass. *Plecoptera*.  
 '39. Harden, Philip H., 207 Civil Courts Bldg., New Orleans, La. *Plecoptera*.  
 '37. Hardy, Capt. D. Elmo, Hdq. Eastern Sector, Office of Surgeon, A. P. O. 629, care of Postmaster, New York, N. Y. *Pipunculidae, Bibionidae*.  
 '36. Harmston, Fred Carl, State Board of Health, Indianapolis, Indiana. *Dolichopodidae*.  
 '07. \*HARNED, R. W., Bur. Ent. & P. Q., Washington, D. C. (F. '27).  
 '33. Harper, Lawrence C., R. 1, Lafayette, N. Y. *Diptera*.  
 '29. HARRIES, F. H., 151 W. 11th Ave., Columbus, Ohio. (F. '43). *Ecology, Physiology*.  
 '23. HARRIS, HALBERT M., Dept. Zool. & Ent., Iowa St. College, Ames, Iowa. (F. '37). *Hemiptera*.  
 '42. Hart, Thomas A., 5556 Kimbark Ave., Chicago, Ill.  
 '39. Hartnack, Hugo, 324 N. 4th St., Tacoma, Washington.



- '21. Hartzell, Albert, Boyce Thompson Inst., Yonkers, N. Y. *Cicadellidae*.  
 '07. Hartzell, F. Z., Agri. Exp. Sta., Geneva, N. Y. *Coleoptera*.  
 Ch. Haseman, Leonard, Univ. Mo., Columbia, Mo. *Psychodidae*.  
 '32. Haskins, Caryl P., 1188 Avon Road, Schenectady, N. Y. *Hymenoptera, esp. Formicidae*.  
 '20. HATCH, MELVILLE H., Dept. Zool., Univ. Wash., Seattle 5, Wash. (F. '38). *Coleoptera*.  
 '38. Hathaway, Edward S., Dept. of Zool., Tulane Univ., New Orleans, La. *Ecology of Marsh Insects*.  
 '32. Haub, James G., Dept. of Zool., Ohio State University, Columbus, Ohio. *Physiology*.  
 '39. Haude, Wm. J., care of John Powell & Co., Inc., 114 E. 32nd St., New York 16, N. Y. *Culicidae*.  
 '30. Haug, Gordon W., Kelowna, British Columbia, Canada. *Formicidae*.  
 '27. Hawkins, J. H., Agri. Exp. Station, Orono, Maine. *Elaterid and Noctuid Larvae*.  
 '32. Hawley, I. M., P. O. Box 150, Moorestown, N. J. *Japanese Beetle*.  
 '35. Haydak, M. H., Ent. Div., University Farm, St. Paul, Minn. *Honeybee Nutrition*.  
 '19. HAYES, WM. P., Entomology Bldg., Univ. Ill., Urbana, Ill. (F. '29). *Larvae*.  
 '31. Heaton, Capt. Robert R., 15th Med. General Lab., A. P. O. 570, care of Postmaster, New York, N. Y. *Fulgoridae, Homoptera*.  
 '34. Hendee, Esther C., Dept. Biology, Russell Sage College, Troy, N. Y. *Isoptera, Hymenoptera*.  
 '32. Henderson, Chas. F., 803 43rd Ave., Gulfport, Miss. *Parasites of Scale Insects*.  
 '31. HENDERSON, LYMAN S., Bur. Ent. & P. Q., Beltsville Research Center, Beltsville, Md. (F. '43). *Carculionidae*.  
 '32. Henderson, W. W., Agri. Exp. Sta., Logan, Utah. *Oedipodinae, Orthoptera*.  
 '29. Hering, Paul, 1058 Piedmont Ave., Atlanta, Ga. *Economic Entomology*.  
 '25. HERMS, WM. B., 112 Agri. Hall, Univ. Calif., Berkeley, Calif. (F. '29). *Med. Entomology*.  
 Ch. HERRICK, GLENN W., 219 Kelvin Place, Ithaca, N. Y. (F. '14). *Thysanoptera, Coccidae*.  
 '43. Hertig, Major Marshall, Sn. C., Box 651, Ancon, Canal Zone.  
 '28. Hickman, J. R., Normal College, Ypsilanti, Mich. *Haliphidae*.  
 '08. HILTON, WM. A., 1263 Dartmouth Ave., Claremont, Calif. (F. '39). *Symphyla, Pauropoda*.  
 '27. HINMAN, E. HAROLD, Apartado 23 bis, Mexico, D. F. (F. '37). *Culicidae*.  
 '33. Hinton, Howard E., Dept. of Entomology, British Museum (Nat. Hist.), Cromwell Road, London, S. W. 7, England. *Dryopidae*.  
 '34. Hitchcock, John David, Intermountain Bee Culture Field Laboratory, Laramie, Wyo. *Bacteriology of Bee Diseases*.  
 '27. Hockenyos, Geo. L., 213 E. Jefferson St., Springfield, Illinois. *Economic Entomology*.  
 '38. Hodge, Charles 4th, Dept. of Biology, Temple Univ., Philadelphia, Pa. *Coleoptera*.  
 Ch. Hodgkiss, H. E., 147 W. Park Avenue, State College, Pa. *Eriophyiidae*.  
 '29. Hodson, A. C., Div. Entomology, Univ. Farm, St. Paul, Minn. (F. '43). *Ecology*.  
 '43. Hoffmann, Anita, Apartado 8026, Mexico, D. F., Mexico.  
 '29. Hoffmann, Clarence H., 157 Tacoma Circle, Asheville, N. C. *Scarabaeidae*.  
 '20. HOFFMANN, WM. E., Lingnan Univ., Canton, China. (F. '39). *Hemiptera*.  
 '35. Holway, Ensign Richard T., South Duxbury, Mass. *Termites*.  
 Ch. HOOD, J. DOUGLAS, Dept. Ent., Cornell Univ., Ithaca, N. Y. (F. '32). *Thysanoptera*.  
 '38. Hoogstraal, Harry, 303 Entomology Bldg., Univ. of Ill., Urbana, Ill. *Morphology*.  
 '34. HORSFALL, WILLIAM R., Dept. Ent., Univ. of Arkansas, Fayetteville, Ark. (F. '43). *Culicidae*.  
 '34. Hoskins, W. M., 112 Agri. Hall, Univ. of Calif., Berkeley, Calif. *Physiology*.  
 '24. Hough, W. S., Winchester, Virginia. *Apple Insects*.  
 Ch. HOUSER, J. S., Agri. Exp. Sta., Wooster, Ohio. (F. '31). *Coccidae*.  
 '39. Hovey, Charles L., Aroostook Farm, Presque Isle, Maine. *Aphidae*.

- Ch. HOWARD, L. O., Bur. Ent. & P. Q., Washington, D. C., (F. '07, H. F. '24).  
*Chalcidoidea*.
- '14. Howard, Neale F., 151 West 11th Ave., Columbus, Ohio. *Mexican Bean Beetle*.
- '43. Howe, 1st Lt. Wayne L., Sn. C., care of Mrs. W. L. Howe, 928 Park Ave., Ft. Lupton, Colo.
- '39. Howland, A. F., 1208 E. Main St., Alhambra, California. *Tomato Insects*.
- '23. HUBBELL, THEO. H., Dept. Biology, Univ. of Florida, Gainesville, Fla. (F. '39). *Orthoptera*.
- '20. HUCKETT, H. C., Long Is. Vegetable Res. Farm, Riverhead, L. I., N. Y. (F. '38). *Muscidae*.
- '39. Hughes, John H., U. S. Quarantine Station, New Orleans (Algiers), La. *Chrysomelidae*.
- '16. HUNGERFORD, H. B., 323 Snow Hall, Univ. Kans., Lawrence, Kans. (F. '27). *Aquatic Hemiptera*.
- '43. Hunt, Charles R., Box 62A, Dryden, Washington.
- '36. Hurlbut, Lt. Herbert S., care of C. S. Hurlbut, West High St., Union City, Pa. *Culicidae*.
- '38. Hutson, Ray, Dept. of Entomology, Michigan State College, E. Lansing, Mich. *Insecticides*.
- '42. Hutzl, John M., Dept. Zool. & Ent., Ohio State Univ., Columbus, Ohio.
- '08. HYSLOP, JAMES A., Arsenal, Silver Spring, Maryland, (F. '35). *Elateridae*.

## I

- '31. IDE, F. P., Dept. Zool., Univ. Toronto, Toronto 5, Ont., Canada. (F. '40). *Ephemeroptera*.
- '19. \*ILLINGWORTH, J. F., Bishop Museum, Honolulu, Hawaii. (F. '40). *Muscoidea*.
- '28. Ingram, J. W., Box 387, Houma, La. *Sugarcane Insects*.
- '14. ISELY, DWIGHT, Box 3, University Station, Fayetteville, Ark. (F. '34). *Chrysomelidae, Curculionidae*.
- '36. Isely, F. B., 2835 W. Gramercy, San Antonio, Texas. *Orthoptera*.
- '22. Ishimori, Naoto, Faculty Agri., Imp. Univ., Hongo, Tokyo, Japan. *Silkworm Diseases*.
- '27. Ives, J. D., Jefferson City, Tenn. *Cave Insects*.
- '34. Ivy, Edward E., Box 1218., Waco, Texas.

## J

- '41. James, Brother Cyprian, Manhattan College, Spuyten Duyvil Pkwy., New York 63, N. Y. *Psyllidae*.
- '38. James, Freshum L., Box 327, Saranac, Michigan. *Coleoptera*.
- '31. JAMES, MAURICE T., Dept. of Ent., Colo. State College, Ft. Collins, Colo. (F. '40). *Stratiomyidae*.
- '30. Janes, Melvin J., Texas Experiment Station, Alta Loma, Texas. *Economic Entomology*.
- '35. Jaques, Harry E., 709 N. Main, Mount Pleasant, Iowa. *Insect Ecology*.
- '30. Jaynes, H. A., 117 Chatham St., Chatham, N. J. *Tiphia of S. A.*
- '25. JEANNEL, RENE, Mus. d'Histoire Naturelle, 45 bis rue de Buffon, Paris 5<sup>e</sup>, France. (F. '30). *Trechus, Anophthalmes*.
- '10. Jennings, H. R., High School of Com., Hayes & Van Ness Ave., San Francisco, Calif. *Diptera*.
- '41. Jensen, Dilworth D., Univ. of Hawaii, Agr. Exp. Sta., Honolulu, T. H.
- '15. Jewett, H. H., Agri. Exp. Sta., Lexington, Ky. *Tobacco and Forage Crop Insects*.
- '43. Jodka, Joseph F. T., Comstock Hall, Cornell Univ., Ithaca, N. Y.
- Ch. JOHANNSEN, O. A., 203 Parkway, Ithaca, N. Y. (F. '14, H. F. '39). *Diptera*.
- '25. Johnson, Frank, 420 Lexington Ave., New York, N. Y.
- '39. Johnson, John W., 111 N. Yale Ave., Fullerton, Calif. *Saturniidae*.
- '26. Johnston, H. G., P. O. Box 751, Phoenix, Arizona. *Miridae, Hemiptera*.
- '27. Jones, Elmer T., 1204 Fremont, Manhattan, Kansas. *Hessian Fly*.
- Ch. Jones, Frank M., 2000 Riverview Ave., Wilmington, Delaware. *Psychidae*.

- '39. Jones, J. R. J. Llewellyn, "Arranmore," R. M. D. No. 1, Cobble Hill, British Columbia, Canada. *Ecology of Lepidopterous Larvae*.
- '41. Jones, Joseph W., Jr., P. O. Box 173, Newbern, Tennessee.
- '40. Just, Theodore K., P. O. Box 126, Notre Dame, Indiana.

## K

- '42. Kadner, Lt. Carl G., Malaria Survey Units, A. S. F., UTC., N. O. S. A., New Orleans 12, La. *Hippoboscidae, Culicidae*.
- '34. Kagy, J. Franklin, care of Dow Chemical Co., P. O. Box 245, Seal Beach, Calif. *Insect Toxicology*.
- '26. Kamal, Mohammed, Parasite Laboratory, Cotton Research B., Giza, Egypt. *Cotton Insects*. (Annals and Statements to be sent to A. Moursi, Citrus Exp. Station, Riverside, Calif.).
- '34. Kearns, Clyde W., Dept. Ent., Univ. of Illinois, Urbana, Ill. *Insecticides*.
- '29. Keck, Capt. Chester B., Box 340, Honolulu, Hawaii. *Ecology*.
- '14. KENNEDY, C. H., Dept. Zool. and Entomology, Ohio St. Univ., Columbus 10, Ohio. (F. '27). *Odonata, Ants*.
- '36. Kessel, Berta B., 35 Elaine Ave., Mill Valley, Calif.
- Ch. Kincaid, Trevor, Univ. Wash., Seattle, Washington. *Psychodidae, Dytiscidae*.
- '12. KING, J. L., Box 150, Moorestown, New Jersey. (F. '32). *Biological Control*.
- '23. KING, KENNETH M., Dominion Entomological Laboratory, Saskatoon, Sask., Canada. (F. '38). *Elateridae Larvae, Noctuidae*.
- '28. KING, WILLARD V., Fourth Corps Area Laboratory, Ft. McPherson, Ga. *Culicidae*. (F. '38).
- '18. KINSEY, ALFRED C., Indiana Univ., Bloomington, Ind. (F. '28). *Cynipidae*.
- '28. Kislanko, J. P., Box 88, Wiggins, Miss. *Aphididae*.
- '38. Klots, Alexander B., Biology Dept., 17 Lexington Ave., New York, N. Y. *Lepidoptera*.
- '11. KNIGHT, H. H., Dept. Zool., St. College, Ames, Iowa. (F. '28). *Hemiptera, Miridae*.
- '40. Knight, Kenneth L., 121 Wesley St., Wheaton, Ill. *Geometrid Larvae*.
- '24. KNOWLTON, GEORGE F., Agri. Exp. Sta., Logan, Utah. (F. '40). *Aphididae*.
- '32. KNOLL, MRS. DOROTHY, 330 E. Dunedin Rd., Columbus 2, Ohio. (F. '43). *Erythroneura*.
- '34. KNOLL, JOSEF N., Dept. Zool. & Ent., Ohio State Univ., Columbus 10, Ohio. (F. '43). *Cleridae, Elateridae, Buprestidae, Cerambycidae*.
- '37. Knutson, Herbert C., U. S. P. H. S., 605 Volunteer Bldg., 66 Luckie St., Atlanta, Ga. *Noctuidae*.
- '17. Kraatz, Walter C., Univ. Akron, Akron, Ohio.
- '42. Krafchick, Bernard, care of Mrs. B. Krafchick, 578 Greene Ave., Brooklyn, N. Y.
- '41. Kramer, Sol, 9 Campus Place, Brooklyn, N. Y.
- '40. Kretzschmar, Lt. (jg) Gerhard, 6807 Ridge Boulevard, Brooklyn, N. Y.
- '34. Krombein, Karl Von Vorse, Division of Insects, U. S. Nat. Mus., Washington, D. C. *Aculeate Hymenoptera*.
- '41. Kuitert, Louis C., 706 Florence St., Kalamazoo, Mich. *Nepidae, Gerridae*.
- '36. Kulash, Walter M., Dept. Zool. & Ent., North Carolina State College, Raleigh, N. C. *Collembola*.

## L

- '28. Lamiman, J. F., 2244 Summer St., Berkeley 7, Calif. *Acarina*.
- '30. LANDIS, B. J., P. O. Box 218, Union Gap, Washington. (F. '40). *Biological Control*.
- '42. Lane, John, Instituto de Higiene de Sao Paulo, Caixa Postal 99B, Sao Paulo, Brazil.
- '40. Lange, W. Harry, Jr., Univ. of California, Court House, P. O. Box 1370, Salinas, Calif. *Lepidoptera*.
- '25. Langford, George S., Dept. Ent., Univ. Maryland, College Park, Md. *Economic Entomology*.
- '17. Langston, James M., A. & M. College, Miss. *Phyllophaga*.
- '37. La Rivers, Ira, Box 1493, Reno, Nevada. *Odonata Psychodidae*.

- '14. Larrimer, W. H., U. S. D. A. Forest Service, Washington, D. C. *Cicadellidae*.  
 '38. Larson, N. P., Hulmeville, Pa. *Physiology*.  
 '37. Lassman, G. W., Bravo No. 12, Jalapa, Vera Cruz, Mexico. *Culicidae*.  
 '13. LATHROP, F. H., Agric. Exp. Station, Orono, Maine. (F. '41). *Cicadellidae*.  
 '40. Latta, Randall, Bur. Ent. & P. Q., Washington, D. C. *Toxicology*.  
 '23. Lauderdale, J. L. E., P. O. Box 2006, Phoenix, Arizona.  
 '17. LAWSON, PAUL B., 2215 Vermont St., Lawrence, Kans. (F. '31). *Cicadellidae*.  
 '39. Leech, H. B., P. O. Box 308, Vernon, British Columbia, Canada. *Coleoptera*.  
 '12. LEIBY, R. W., Comstock Hall, Cornell Univ., Ithaca, N. Y. (F. '40).  
*Embryology*.  
 '38. Leonard, Justin W., Hunt Creek Exp. Sta., P. O. Box 5, Lewiston, Mich.  
*Aquatic Insects*.  
 '28. Leonard, Mortimer D., 2480 16th St. N. W., Washington, D. C. *Aphididae*.  
 '34. Le Veque, Norma, 2135 Fourth St., Boulder, Colo. *Apoidea*.  
 Lewis, Mrs. W. M., Division of Entomology, University of California College  
 of Agri., Davis, Calif.  
 '33. Lilly, John H., King Hall, Univ. of Wis., Madison 6, Wis. *Coleophoridae*.  
 '34. Lindgren, David L., Univ. of Calif., Citrus Exp. Sta., Riverside, Calif.  
*Toxicology*.  
 '39. Lindquist, Arthur W., Box 3391, Orlando, Fla. *Chironomidae*  
 '17. LINDSEY, A. W., Box 612, Granville, Ohio. (F. '40). *Hesperioidea*.  
 '33. \*LINSLEY, E. GORTON, 112 Agricultural Hall, University of California, Berkeley,  
 Calif. (F. '41). *Cerambycidae of World Coleoptera of N. Am.*  
 '25. LIST, GEO. M., Agri. College, Fort Collins, Colo. (F. '32). *Cimicidae*.  
 '30. Livingston, E. M., 0-502994, Hq. 7th Army, A. P. O. 758, care of Postmaster,  
 New York, N. Y.  
 '31. Lloyd, Llewellyn, University, Leeds, England.  
 '19. Lobdell, Mrs. Gladys H., Rt. 2, Brevard, N. C. *Coccidae*  
 '30. Loftin, U. C., Bureau Entomology & P. Q., Washington, D. C.  
 '38. Ludwig, Daniel, Dept. of Biology, N. Y. Univ., 181st St. and Univ. Ave.,  
 New York 53, N. Y. *Physiology*.  
 '13. LUGHBILL, PHILIP, Box 495, Lafayette, Ind. (F. '41) *Phyllophaga*.  
 Lund, Lt. (jg) Horace O., Naval Air Station, (LTA) Weeksville, Elizabeth  
 City, N. C. *Culicidae*.  
 '31. Lyle, Clay, State College, Miss. *Crustacea*  
 '40. Lyman, F. Earle, care of T. V. A., Norris, Tenn. *Aquatic Insects*,  
*Ephemeroptera*.

## M

- '43. Mackenzie, G. P., 1284 Sherwood Road, San Marino 9, Calif.  
 '32. MacLeod, Guy F., 1628 N. Fort Meyr Drive, Arlington, Va. *Physiology*.  
 '40. MacSwain, J. W., 2620 Stuart St., Berkeley, California.  
 '20. McBride, O. C., Box 340, Honolulu 9, Hawaii. *Insecticides*.  
 '43. McCall, George L., Dept. Ent., Dupont Exp. Station, Wilmington, Del.  
 '29. McClure, H. Elliott, 315 S. 17th St., Ord, Nebraska. *Ecology*.  
 '17. McCracken, ISABEL, Box 1545, Stanford University, Calif. (F. '39). *Apoidea*.  
 '10. McDaniel, Eugenia, Agri. College, East Lansing, Mich. *Coccidae, Orthoptera*.  
 '30. McGovran, E. R., Bureau of Ent. & Plant Quar., Nat. Agr. Res. Center,  
 Beltsville, Md. *Toxicology*.  
 '11. McINDOO, N. E., 7225 Blair Rd., Takoma Park, Washington 12, D. C. (F.  
 '34). *Insect Physiology*.  
 '32. McKinstry, Arthur Porter, 320 Normandy, Modesto, Calif. *Microvelia*.  
 '32. Madden, A. H., Bur. Ent. & Plant Quar., Box 3391, Orlando, Fla. *Economic  
 Entomology*.  
 '41. Maddock, Darrell R., 450 Cross St., Ogden, Utah.  
 '17. Maheux, Georges, Dept. Agri., Parliament Bldg., Quebec, Canada. *Forest  
 Insects*.  
 '43. Maina, Bartholomew A., 10623 Church St., Chicago 43, Illinois.  
 '40. Mangrum, James F., Lincoln Memorial Univ., Harrogate, Tenn. *Acarina*.  
 '21. \*Mank, Edith Webster, 12 Reservoir St., Lawrence, Mass. *Coleoptera*.  
 '21. Mank, Helen G., 12 Reservoir St., Lawrence, Mass.  
 '13. \*MANN, WM. M., Nat. Zool. Park, Washington, D. C. (F. '37). *Formicidae*

- '23. Manter, Jerauld A., Agri. College, Storrs, Conn. *Economic Entomology*.
- '37. Manzelli, Manlio, 25 Leland Ave., Plainfield, N. J. *Hemiptera*.
- '35. \*Maple, John D., P. O. Box 47, Yokohama, Japan. *Physiology*.
- '38. March, Ralph B., 376 Merritt, Oshkosh, Wis.
- '22. Marcovitch, S., University Farm, Knoxville, Tenn. *Insecticides*.
- '37. Markos, Basil G., 17 Mechanic St., Dover, New Hampshire. *Toxicology*.
- Ch. MARLATT, C. L., 1521-16th St., N. W., Washington, D. C. (F. '07, H. F. '41). *Coccidae*.
- Ch. MARSHALL, W. S., 139 E. Gilman St., Madison 3, Wis. (F. '17). *Morphology*.
- '25. Martin, Chas. H., 4221-1/8 Burns, Los Angeles 27, Calif. *Ecology*.
- '43. Martin, Esmond B., 465 E. 57th St., New York 22, N. Y.
- '34. Martorell, Luis F., Agri., Exp. Station, P. O. Box, 614, Rio Piedras, Puerto Rico. *Sugar Cane, Forest Insects*.
- '38. Marvin, Philip H., Box 150, Moorestown, N. J. *Biology of Melittobia*.
- '21. Mason, Arthur C., Box 150, Moorestown, N. J. *Thysanoptera*.
- '30. Mason, Horatio C., 298 Blenheim Rd., Columbus 2, Ohio. *Tomato Fruitworm*.
- Ch. MATHESON, ROBT., Cornell Univ., Ithaca, N. Y. (F. '28). *Ixodoidea, Culicidae*.
- '34. Maxson, Asa C., P. O. Box 46, Longmont, Colo. *Aphidae*.
- '36. Mead, Albert R., 1035 Franklin St., Santa Clara, Calif. *Chrysomelidae*.
- '37. Medler, John T., 921 N. 3rd St., Albuquerque, N. M. *Cicadellidae*.
- '25. Meiners, Edwin, Rm. 238, 6651 Enright, St. Louis 5, Mo. *Lepidoptera*.
- '32. Melampy, R. M., Dept. Zool., Louisiana State Univ., Baton Rouge, La. *Physiology*.
- Ch. MELANDER, A. L., 4670 Rubidoux Drive, Riverside, Calif. (F. '14). *Diptera*.
- '27. Melvin, Roy, 5501 Willis, Dallas 6, Texas. *Physiology*.
- '42. Mendall, Seaton C., Hammondsport, N. Y.
- '33. Menusan, Henry, Jr., Div. of Extension, Penn. State College, State College, Pa. *Physiology, Ecology*.
- '32. Merino, Gonzalo, Bureau Plant Industry, Manila, P. Is. *Cicadellidae*.
- '23. Merrill, G. B., Plant Board, Seagle Bldg., Gainesville, Fla. *Coccidae, Aleyrodidae*.
- '12. METCALF, C. L., Dept. Entomology, Univ. Ill., Urbana, Ill. (F. '20). *Syrphidae*.
- '39. Metcalf, Robert L., Health and Safety Dept., Tennessee Valley Authority, Wilson Dam, Ala. *Insect Physiology*.
- '09. METCALF, Z. P., State College Station, Raleigh, North Carolina. (F. '34). *Homoptera*.
- '35. MICHELbacher, A. E., 112 Agri. Hall, Univ. of Calif., Berkeley, Calif. (F. '41). *Symphyla, Apoidea*.
- '37. Michener, Charles D., Post Surgeon's Office, Camp Shelby, Miss. *Apoidea*.
- '17. MICKEL, CLARENCE E., Div. Ent., Univ. Farm, St. Paul, Minn. (F. '35). *Mutillidae*.
- '36. Miller, Albert, Dept. Tropical Medicine, Tulane Univ., 1430 Tulane Ave., New Orleans, La. *Culicidae*.
- '31. Miller, Albert C., Box 2038, Pittsburgh, Pa. *Membracidae*.
- '42. Miller, E. Morton, Dept. Zoology, Univ. of Miami, Coral Gables, Fla.
- '30. Miller, Forrest W., Biology Dept., Hartwick College, Oneonta, N. Y. *Aphididae*.
- '37. Milliron, Herbert E., Dept. of Entomology, Purdue Agri. Exp. Station, Lafayette, Indiana. *Chalcidoidea, Bombidae*.
- '29. MILLS, HARLOW B., Dept. of Ent., Montana State Coll., Bozeman, Montana. (F. '37). *Collembola*.
- '37. Milne, Lorus J., Johnson Foundation, Univ. Penna., Philadelphia 4, Pa. *Trichoptera*.
- '25. Milum, Vern G., 104 Exp. Zool. Lab., Univ. of Ill., Champaign, Ill. *Apiculture*.
- '43. el Minchaoui, Ibrahim, P. O. B. 763, Cairo, Egypt.
- '26. MINNICH, D. E., Dept. Zool., Univ. Minn., Minneapolis, Minn. (F. '39). *Behavior*.
- '38. Miroyiannis, Stanley D., Dept. of Biology, Northeastern Univ., Boston, Mass. *Histology*.
- '39. Mitchell, Robert T., Patuxent Research Refuge, Bowie, Md. *Ichneumonidae and Braconidae*.

- '21. MITCHELL, T. B., State College, Raleigh, N. Carolina. (F. '37). *Apoidea, Megachile*.
- '22. MONTGOMERY, B. ELWOOD, Dept. Ent., Purdue Univ., Lafayette, Ind. (F. '31). *Odonata*.
- '39. Moore, Geo. A., 359 Querbes Ave., Outremont, Quebec, Canada. *Hemiptera*.
- '39. Moore, Warren, Bon Air, Va. *Dermestidae*.
- Ch. Morgan, H. A., University Library, Univ. of Tennessee, Knoxville, Tenn. Send mail to 2424 Kingston Pike, Knoxville, Tenn.
- '27. Morgan, W. P., R. R. 6, Box 414, Indianapolis, Ind. *Dermaptera*.
- Ch. MORRILL, A. W., 1505 Winchester Ave., Glendale, 1, Calif. (F. '39).
- '12. MORRISON, HAROLD, Bureau of Entomology and Plant Quarantine, Washington, D. C. (F. '28). *Coccidae*.
- '08. MOSHER, EDNA, R. R. No. 1, Newport, Nova Scotia, Canada. (F. '20). *Lepidoptera*.
- '20. Mote, Don C., St. Agri. College, Corvallis, Oregon. *Economic Entomology*.
- '29. MOULTON, DOUDLEY, 35 Elwood St., Redwood City, Calif. (F. '31). *Thysanoptera*.
- '15. MUESEBECK, C. F. W., Bureau of Entomology and Plant Quarantine. Washington, D. C. (F. '34). *Braconidae, Bethyridae*.
- '36. Mulrennan, J. A., State Board of Health, Box 210, Jacksonville 1, Fla. *Culicidae*.
- '43. Muma, Martin H., 4504 Guildford Rd., College Park, Md.
- '27. \*Munro, J. A., State College Station, Fargo, North Dakota. *Orthoptera, Diptera*.
- '35. \*Murray, William D., 4460 Rosemary Parkway, Columbus 2, Ohio. *Sphecidae*.
- '28. MUSGRAVE, ANTHONY, Australian Museum, College St., Sydney, New South Wales, Australia. (F. '41). *Nycteribiidae*.
- '27. Musgrave, Paul N., 1956 Underwood Ave., Huntington, W. Va. *Dryopidae*.

## N

- '35. Nagel, R. H., 420 Foster Ave., Coeur d'Alene, Idaho.
- Ch. NEEDHAM, J. G., 6 Needham Place, Ithaca, N. Y. (F. '07, H. F. '35). *Odonata, Ephemera*.
- '21. Neiswander, C. R., Ohio Agr. Exp. Sta., Wooster, Ohio. *Insects of Ornamentals*.
- '28. Neiswander, R. B., Agri. Exp. Sta., Wooster, Ohio. *Fruit Insects*.
- '39. Nesbitt, Herbert H. J., 34 Lakeside Ave., Ottawa, Ontario, Canada. *Acarina*.
- Ch. Ness, Henry, 821 Kellogg Ave., Ames, Iowa. *Economic Entomology*.
- '34. Nevin, F. Reese, School of Hygiene and Pub. Health, Johns Hopkins Univ., 615 N. Wolfe St., Baltimore, Md. *Morphology of Acarina*.
- Ch. Newcomer, E. J., Box 1291, Kakima, Washington. *Fruit Insects*.
- '15. Newman, Geo. B., 246 E. Hamilton Ave., State Coll., Pa. *Insect Histology*.
- '28. Newton, Richard C., Bureau of Ent. & Plant Quar., Bozeman, Montana. *Alfalfa Weevil*.
- '38. Nicholson, H. Page, U. S. Public Health Service, 300 Essex Bldg., Norfolk 10, Va. *Simuliidae*.
- '31. Nickels, C. B., Box 209, Bureau of Entomology, Brownwood, Texas. *Pecan Insects*.
- '22. Noble, W. B., Bur. of Ent. & Pl. Q., Box 1857, Sacramento 9, Calif. *Hessian Fly*.
- '38. Noland, Lowell E., Biology Bldg., Univ. of Wisconsin, Madison, Wis.
- '17. \*Notman, Howard, Circle Rd., Dougan Hills, Staten Island, N. Y. *Carabidae, Staphylinidae*.
- '43. Nushawg, William N., 292 Sycamore St., East Aurora, N. Y.
- '37. Nye, William P., care of Ray Whipple, St. George, Utah. *Forest Insects*.
- '31. O'Byrne, Harold I., R. F. D. No. 1, Box 792, Glencoe, Mo. *Ecology Lepidoptera*.
- '08. O'KANE, WALTER C., Durham, New Hampshire. (F. '24).
- '29. OMAN, PAUL W., Bur. Ent. & P. Q., Washington, D. C. (F. '40). *Homoptera*.

- '37. O'Neill, William J., Tree Fruit Branch Exp. Sta., Box 596, Wenatchee, Wash. *Fruit Insects*.  
 '34. Oosthuizen, M. J., School of Agriculture, Potchefstroom, South Africa. *Stored Grain Insects*.  
 Ch. OSBORN, HERBERT, Ohio St. Univ., Columbus 10, Ohio. (F. '07, H. F. '28). *Homoptera, Cicadellidae*.  
 '08. Osborn, H. T., 1 Highland Ave., Los Gatos, Calif. *Cicadellidae*.  
 Ch. OSBURN, R. C., Ohio State Univ., Columbus 10, Ohio. (F. '17). *Syrphidae*.  
 '43. Osmun, Lt. John V., Medical Branch, Hdq. 2nd Serv. Command, Governors Island, New York 4, N. Y.  
 '20. Otanes, Faustino Q., Bureau of Plant Industry, Manila, Philippine Is. *Economic Entomology*.  
 '36. Owen, Wm. Bert, Dept. of Zool., Univ. of Wyoming, Laramie, Wyo. *Culicidae*.  
 '25. OZHURN, REG. H., Ont. Agri. College, Guelph, Ontario, Canada. (F. '43). *Insect Histology*.

## P

- '15. Packard, Clyde M., Bureau of Ent. & Plant Quar., Washington, D. C. *Cereal and Forage Insects*.  
 '18. Painter, H. R., 705 Bexley Road, West Lafayette, Indiana. *Phyllophaga*.  
 '19. PAINTER, R. H., Dept. Ent., K. S. C., Manhattan, Kansas. (F. '35). *Diptera, Bombyliidae*.  
 '39. Palm, Charles E., Dept. Ent., Cornell Univ., Ithaca, N. Y. *Forage Crop Insects*.  
 '37. Palmer, Boyd B., Polytechnic Institute, San German, Puerto Rico. *Trichoptera*.  
 '27. PALMER, MIRIAM A., 621 S. Howes St., Fort Collins, Colo. (F. '37). *Aphidae*.  
 '27. PARK, ORLANDO, Dept. Zool., Northwestern Univ., Evanston, Ill. (F. '40). *Pselaphidae*.  
 '39. Parker, Barbara M., 437 Hibbard Rd., Wilmette, Ill.  
 '25. PARKER, H. L., South American Parasite Lab., Blanca del Tabare, 2950, Montevideo, Uruguay. (F. '40). *Parasitic Hymenoptera*.  
 '37. Parker, J. R., Bureau of Ent. & Pl. Quar., Bozeman, Montana. *Orthoptera*.  
 '24. Parker, R. L., Dept. Ent., K. S. C., Manhattan, Kansas. *Apiculture*.  
 '18. Parks, T. H., Dept. Ent., Ohio St. Univ., Columbus 10, Ohio.  
 '24. Parman, D. C., Box 509, Uvalde, Texas. *Diptera*.  
 '43. Parr, Thaddeus, Box 156, Bexley Station, Columbus 9, Ohio.  
 Ch. PARROTT, P. J., Agri. Exp. Sta., Geneva, N. Y. (F. '14).  
 '12. PARSHLEY, H. M., Dept. Zool., Smith College, Northampton, Mass. (F. '43). *Heteroptera*.  
 '32. Parsons, Carl T., 205 West 57th St., New York, N. Y.  
 '34. Parton, Herbert L., Div. of Ent., Univ. Farm, St. Paul, Minn. *Greenhouse Insects*.  
 '32. Passos, Cyril F. dos, Washington Corners, Mendham, N. J. *Lepidoptera*.  
 Ch. \*PATCH, EDITH M., P. O. Box 150, Orono, Maine. (F. '14). *Aphididae*.  
 '35. Paulian, Renaud, Laboratoire d'Entomologie, Museum d'Histoire Naturelle, 45 bis Rue de Buffon, Paris V, France. *Scarabaeidae, Corylophidae*.  
 '35. Paullus, Harold J., DeSoto, Missouri.  
 '23. \*PAYNE, NELLIE M., care of American Cyanamid Co., Boston Post Road, Stamford, Conn. (F. '40). *Physiology*.  
 '20. PEAIRS, L. M., Morgantown, West Va. (F. '40).  
 '34. Pechuman, La Verne L., 7 Davison Road, Lockport, N. Y. *Tabanidae*.  
 '40. Pederson, Lt. Calvin E., N. A. T. B. Medical Office, Ft. Pierce, Fla.  
 '37. Pelton, John Z., 205 First Ave., Waverly, Ohio. *Aquatic Insects*.  
 '35. Penner, Lawrence R., Dept. Zoology, University of Connecticut, Storrs, Conn. *Araeopidae*.  
 '30. Pepper, Bailey B., Dept. Ent., Agri. Exp. Sta., New Brunswick, N. J. *Biological Control*.  
 '32. Pepper, James Hubert, Mont. State College, Bozeman, Mont. *Insecticides*.  
 '29. Peters, Harold T., Div. of Ent., University Farm, St. Paul, Minn. *Siphonaptera*.

- '39. Peterson, Allan G., St. Board of Health, Jackson 113, Miss. *Potato Insects*.  
'11. PETERSON, ALVAH, Dept. Ent., Ohio St. Univ., Columbus 10, Ohio. (F. '28).  
*Biological Control*.  
'37. Peterson, Lloyd O. T., Indian Head, Saskatchewan, Canada. *Forest Entomology*.  
'39. Petrakis, Manuel M., Rm. 128, Natural Resources Bldg., Univ. of Ill., Urbana, Ill.  
'40. Pettit, Lincoln C., 59 Harrison Ave., Baldwin, Long Island, N. Y. *Der-mestidae*.  
Ch. PETTIT, R. H., Dept. Ent., Michigan State College, East Lansing, Mich. (F. '39). *Coccidae*.  
'07. PETRUNKEVITCH, ALEXANDER, Yale Univ., New Haven, Conn. (F. '37). *Arachnida*.  
'43. Pfadt, Robert E., Dept. Ent., Univ. of Wyoming, Laramie, Wyo.  
'21. PHILLIPS, E. F., Cornell Univ., Ithaca, N. Y. (F. '29). *Apiculture*.  
'12. Phillips, W. J., 718 Cargill Lane, Charlottesville, Va. *Harmolita*.  
'37. Phillips, W. Levi, 985 South Third East, Salt Lake City, Utah. *Lepidoptera*.  
Ch. PIERCE, W. DWIGHT, Los Angeles County Museum, Exposition Park, Los Angeles 7, Calif. (F. '30). *Rhynchophora*.  
'41. Platt, Fred R., Deputy Agri. Commissioner, Court House, Riverside, Calif. *Coccidae*; *Coleoptera*.  
'41. Pletsch, Don, Dept. of Entomology, Montana State College, Bozeman, Mont. *Psyllidae*, *Myrmeleonidae*.  
'28. Plummer, C. C., Apartado Num. 3, Colonia Anahuac, Mexico, D. F., Mexico. *Membracidae*.  
'18. POOS, FRED W., Beltsville Research Center, Beltsville, Md. (F. '43).  
'23. Porter, B. A., Bureau Entomology & Pl. Q., Washington, D. C. *Fruit Insects*.  
'43. Porter, John E., Asst. Sanitarian (R), U. S. Public Health Service, Malaria Control in War Areas, Foreign Quarantine Service, 309 U. S. Court House, Fort Worth 2, Texas.  
'26. Potts, Samuel F., 56 Hillhouse Ave., New Haven, Conn. *Toxicology*, *Physiology*.  
'36. \*Pratt, Harry D., U. S. Public Health Service, District No. 6, San Juan, Puerto Rico. *Ichneumonidae*.  
'16. Price, W. A., Univ. Ky., Lexington, Ky. *Economic Entomology*.  
'32. \*PRITCHARD, A. EARL, 2307 N. W. 19th, Oklahoma City 7, Okla. (F. '43). *Asilidae*, *Itionidae*.  
'40. Pritchett, John C., 22 Federal Office Bldg., Seattle 33, Wash.  
'28. PROCTER, WM., Bar Harbor, Maine. (F. '40). *Insects of Mt. Desert Region*.  
'33. Putman, W. L., Dom. Ent. Lab., Vineland Sta., Ontario, Can. *Chrysopidae*.

## Q

- '36. Quarterman, Kenneth D., Box 989, Gulfport, Miss. *Cimicidae*.

## R

- '42. Ramsay, Maynard J., 2919 Curtis St., Elmhurst, N. Y.  
'43. Rapp, William F., Jr., N. J. Agri. Exp. Station, New Brunswick, N. J.  
'14. RAU, PHIL, 549 E. Argonne Drive 22, Kirkwood, Mo. (F. '27). *Hymenoptera*, *Behavior*.  
'42. Reade, Ritchard, British Military Hospital, Kingston, Jamaica, B. W. I.  
'23. READIO, PHILIP A., Dept. of Ent., Cornell Univ., Ithaca, N. Y. (F. '37). *Reduviidae*.  
'23. Reed, Lt. W. D., Office of the Chief Engineer, New War Bldg., Rm. 6007, Washington, D. C. *Tobacco Insects*.  
'30. Rees, Don M., Univ. Utah, Salt Lake City, Utah. *Culicidae*.  
'23. Reeves, Jos. A., 415 Federal Bldg., Buffalo, N. Y. *Chrysomelidae*, *Fulgoridae*.  
Ch. REHN, J. A. G., Acad. Nat. Science, Logan Square, Philadelphia, Pa. (F. '14). *Dermoptera*, *Orthoptera*.  
'43. Remington, Charles L., 5570 Etzel Ave., St. Louis, Mo.  
'34. Rice, Paul L., Dept. of Entomology, Agri. Exp. Sta., Newark, Delaware. *Chalcidoidea*.



- '30. RICHARDS, A. GLENN, JR., Zoological Laboratories, Univ. of Penn., 38th St. and Woodland Ave., Philadelphia 4, Pa. (F. '38). *Noctuidae*.
- '14. RICHARDSON, CHAS. H., Dept. Ent., Ia. St. Coll., Ames, Ia. (F. '31). *Physiology*.
- '29. RICHARDSON, LT. H. H., Port Surgeon's Office, New York Port of Embarkation, Brooklyn, N. Y. (F. '41). *Physiology*.
- '28. Richmond, Major Edward A., Tech. Div. C. W. S., Camp Detrick, Md. *Hydrophilidae*.
- '39. Riedel, F. Atherton, Morehead State Teachers College, Morehead, Ky.
- '43. Rieder, Robert E., Ext. Ent. & Plant Pathologist, Oregon State College, Corvallis, Oregon.
- '39. Reigel, Capt. Garland T., 2418 So. Scoville Ave., Berwyn, Ill. *Braconidae*.
- '22. Ries, Donald T., Starved Rock State Park, Utica, Ill. *Cephidae, Siricidae*.
- '40. Riherd, Lt. (jg) Paul T., Genl. Del., Stephenville, Texas. *Culicidae*.
- '29. Riley, Merrill K., Box 38, Kaneohe, T. H. *Coccidae*.
- Ch. RILEY, WM. A., Div. Ent., Univ. Farm, St. Paul, Minn. (F. '14). *Parasitology*.
- '39. Rings, 2nd Lt. Roy W., 1879 Unit, 8th Service C., Camp Livingston, La. *Cerambycidae*.
- '33. Ritcher, Paul O., Agr. Exp. Station, Lexington, Ky. *Phyllophaga*.
- '36. Ritchie, 1st Lt. C. L., Post Surgeon's Office, Fort Mason, Calif. *Coccidae, Lepidopterous Larvae*.
- '25. Rivnay, Ezekiel, Agri. Exp. Sta., Rehoboth, Palestine. *Thysanoptera*.
- '39. Roark, R. C., Bur. Ent. & P. Q., U. S. D. A., Washington, D. C. *Insecticides*.
- '40. Roberts, H. Radclyffe, Villa Nova, Pa. *Acrididae*.
- '31. Roberts, J. Harvey, Box 8729, University, La. *Trichoptera*.
- '28. Roberts, R. A., 1104 S. Runnels St., Big Spring, Texas. *Mantidae*.
- '43. Roberts, Reed S., 346 W. First No., Logan, Utah.
- '15. Robinson, J. M., Box 671, Auburn, Alabama.
- '26. ROBINSON, WM., Burnt Mills Hills, Silver Spring, Maryland. (F. '39). *Physiology*.
- '41. Rockstein, S/Sgt. Morris, 2nd Weather Squadron, Lockbourne AAB, Columbus 17, Ohio.
- '13. Rockwood, L. P., Forest Grove, Oregon. *Noctuidae, Orthoptera*.
- '31. Rodeck, Hugo G., Univ. Colo. Museum, Boulder, Colo. *Nomada*.
- '15. ROGERS, J. SPEED, Box 2666 Univ. Sta., Gainesville, Fla. (F. '43). *Tipulidae*.
- '41. \*Rogoff, Ensign William M., H-V(S), USNR, Sanitation Department, Station Hosp., Camp Peary, Va.
- '27. ROHWER, S. A., Bur. Ent. & Pl. Q., Washington, D. C. (F. '29). *Hymenoptera*.
- '25. Rosewall, O. W., Box 8729, Dept. Ent., Louisiana State Univ., Baton Rouge, La. *Coleoptera, Pentatomidae*.
- '39. Ross, Lt. Edward S., Dept. Ent., Calif. Acad. Science, Golden Gate Park, San Francisco, Calif. *Histeridae, Embioptera*.
- '31. ROSS, HERBERT H., St. Nat. Hist. Surv., Urbana, Ill. (F. '37). *Tenthredinidae*.
- '12. Ross, Wm. A., Vineland Station, Ontario, Canada. *Aphididae*.
- '40. Roth, Louis M., 351 East 45th St., Brooklyn 3, N. Y.
- '36. Rozeboom, Lloyd Eugene, School of Hygiene and Public Health, 615 N. Wolf St., Baltimore, Md. *Culicidae*.
- '14. Ruckes, Herbert, 167-11 33rd Ave., Flushing, L. I., New York. *Pentatomidae*.
- '39. Rude, Clifford S., Box 96, Menard, Texas. *Ixodidae*.
- Ch. RUGGLES, A. G., University Farm, St. Paul, Minn. (F. '35).
- '42. Ryan, George S., care of C. H. Elliott, Angola, Indiana.

## S

- '33. \*SABROSKY, CURTIS W., Dept. of Ent., Mich. State Coll., East Lansing, Mich. (F. '41). *Chloropidae*.
- '41. Sailer, Reece I., Division of Insects, U. S. National Mus., Washington, D. C. *Hemiptera*.
- '38. Sailsbury, Murl B., 824 Gaffield Place, Evanston, Ill. *Chrysomelid larvae*.
- '29. Sakimura, Kay, Pineapple Research Inst., Honolulu 2, Hawaii. *Thysanoptera*.

- '37. Sampson, William W., 156 So. 14th St., Richmond, Calif. *Aphididae, Aleurodidae*.
- '31. SANDERSON, MILTON W., Ill. State Nat. Hist. Survey, Urbana, Ill. (F. '43). *Coleoptera*.
- '07. SATTERTHWAIT, A. F., 806 Ohio St., Urbana, Ill. (F. '30). *Calendra*.
- '29. Scaramuzza, L. C., Central Baragua, Prov. of Camaguay, Cuba. *Sugar Cane Insects*.
- '30. Schaefer, Paul E., Dept. Zool., Univ. of New Hampshire, Durham, N. H. *Morphology*.
- '30. Schlosberg, Morris, P. O. Box 606, West Lafayette, Ind. *Lepidoptera*.
- '29. Schmidt, Carl T., Box 3166, Honolulu, Hawaii. *Ecology*.
- '33. Schmidt, Helen D. O'Neil, Box 3166, Honolulu, Hawaii. *Trichoptera*.
- '20. Schmieder, Rudolf G., Zool. Lab., Univ. Pa., Philadelphia, Pa.
- '32. SCHMITT, JOHN B., Dept. Ent., N. J. Agri. Exp. Sta., New Brunswick, N. J. (F. '43). *Morphology*.
- '34. Schmitt, T. J., Jr., Apt. 16, 1086 Corona St., Denver 3, Colo. *Scolytidae*.
- Ch. Schoene, W. J., Agri. Exp. Sta., Blacksburg, Va.
- '36. Schoof, Herbert F., M. C. W. A., N. C. State Bd. of Health, Raleigh. N. C. *Chrysomelidae*.
- '29. Schroeder, H. O., 623 W. Concord, Orlando, Fla. *Ixodoidea, Argasidae*.
- '37. Schroeder, Philip M., 1979 Ashland Ave., St. Paul, Minn. *Forest Insects*.
- '40. Schuh, Joe, Dept. Ent., Oregon State College, Corvallis, Oregon. *Odonata*.
- '32. Schumaker, George K., 1515 Chew St., Allentown, Pa. *Coleoptera*.
- '26. SCHWARDT, H. H., Dept. Ent., Cornell Univ., Ithaca, N. Y. (F. '35). *Tabanidae*.
- '26. SCHWARZ, HERBERT F., Am. Mus. Nat. Hist., 77th St. & Cent. Park West, New York, N. Y. (F. '37). *Meliponidae*.
- '28. Scotland, Minnie B., 42 Continental Ave., Cohoes, N. Y. *Lemna Insects*.
- '25. SCULLEN, H. A., Dept. Entomology, Oregon State College, Corvallis, Ore. (F. '40). *Cerceridae*.
- '23. Seamans, H. L., Dom. Ent. Lab., Lethbridge, Alberta, Canada. *Muscoidea*.
- '41. Sears, Jack W., B. L. 401, Univ. of Texas, Austin, Texas.
- '36. Seevers, Charles, Central Y. M. C. A. College, 19 South LaSalle St., Chicago, Ill. *Termitophiles*.
- '38. Semans, F. Merrick, North Jackson, Ohio.
- '08. SEVERIN, H. C., South Dakota State College, Brookings, S. D. (F. '39). *Orthoptera, Homoptera, Heteroptera*.
- '07. SHAFER, GEO. D., 321 Melville Ave., Palo Alto, Calif. (F. '41). *Physiology*.
- '18. \*SHANNON, R. C., Malaria Bureau, P. O. Box 556, Port of Spain, Trinidad, B. W. I. (F. '34). *Diptera*.
- '35. Shaw, Frank R., Fernald Hall, Mass. State College, Amherst, Mass. *Mycetophilidae*.
- '29. Shaw, John G., Laboratorio Entomologico, Apt. Num. 3, Colonia Anhuac, D. F., Mexico.
- Ch. SHELFORD, V. E., Vivarium Bldg., Wright and Healy Sts., Champaign, Ill. (F. '20). *Ecology*.
- '43. Shenefelt, Roy D., Zool. Dept., Washington State College, Pullman, Wash.
- '22. SHEPARD, HAROLD H., 4362 N. Pershing Drive, Arlington, Va. (F. '39). *Hesperidae*.
- '17. Sherman, Franklin, Div. Ent., Clemson College, South Carolina. *Acrididae, Cerambycidae, Cicindelidae*.
- '11. SHERMAN, JOHN D., JR., 132 Primrose Ave., Mt. Vernon, N. Y. (F. '39). *Dytiscidae*.
- '34. Shields, Lt. S. E., Grand River, Iowa. *Culicoides*.
- '35. \*SHOCKLEY, Wilfred, 1180 Sherman St., Denver 3, Colo. *Cerambycidae, Decticinae*.
- '28. Shropshire, Leslie H., California Packing Corp., Rochelle, Ill. *Economic Entomology*.
- Ch. SHULL, A. FRANKLIN, 431 Highland Rd., Ann Arbor, Mich. (F. '39). *Aphididae*.
- '43. Siegel, Irving, 657 Crotona Park N., New York 57, New York.
- '15. SILVESTRI, FILIPPO, Scuola Superiore d'Agricoltura, Portici, Italy. (F. '20). *Thysanura, Protura, Termites, Myrizapoda*.

- '32. Silvey, J. K. Gwynn, Dept. of Biology, North Texas State Teachers' College, Denton, Texas. *Coleoptera*.
- '35. Simizu, Tanehisa, Imp. Pl. Quar. Serv., Nagoya Custom House, Nagoya, Japan. *Bruchidae, Diptera*.
- '42. Simmonds, Frederick J., Imperial Parasite Service, Belleville, Ontario, Canada.
- '29. Simmons, Perez, 712 Elizabeth St., Fresno 3, Calif. *Dried Fruit Insects*.
- '30. Simmons, S. W., Box 547, U. S. Pub. Health Service, Carter Mem. Lab., Savannah, Ga. *Medical Entomology*.
- '39. Simonds, Wm. E., Agricultural Bldg., Embarcadero and Mission, San Francisco, Calif. *Elateridae*.
- '30. \*Simpson, Geddes W., Holmes Hall, Orono, Me. *Insects and Plant Diseases*.
- '38. Singleton, J. M., 209 River St., Hoboken, N. J. *Quarantines*.
- '43. Slifer, Eleanor H., Dept. Zool., Univ. of Iowa, Iowa City, Iowa.
- '32. Smith, Carroll N., P. O. Box 78, Savannah, Ga. *Ixodidae*.
- '32. Smith, Chas. E., Agricultural Center, University, La. *Truck Crop Insects*.
- '35. Smith, Clyde F., Dept. of Entomology, Univ. of North Carolina, Raleigh, N. C. *Aphididae*.
- '27. SMITH, FLOYD F., Research Center, Beltsville, Maryland. (F. '43).
- '35. Smith, Frank K., 2228 Elizabeth St., Pueblo, Colo. *Aquatic Coleoptera*.
- '28. Smith, Herbert D., 209 River St., Hoboken, N. J. *Ichneumonidae*.
- '35. Smith, Howard W., Rear 186 West Woodruff Ave., Columbus, Ohio.
- '37. Smith, Marion E., 103 Broadway, Ocean Grove, N. J. *Arctiidae*.
- '19. SMITH, MARION R., Rm. 377, U. S. National Museum, Washington, D. C. (F. '38). *Formicidae*.
- '39. Smith, Myron W., 632 Dermon Bldg., Memphis, Tenn. *Curculionidae*.
- '36. Smith, Ralph H., Univ. of Calif., 405 Hilgard Ave., Los Angeles, Calif. *Hemiptera*.
- '42. Smith, Ray F., 112 Agri. Hall, Univ. of California, Berkeley, Calif.
- '14. SMITH, ROGER C., 2009 Twentieth Road North, Arlington, Va. (F. '31). *Neuroptera*.
- '38. Smith, Septima C., Box 1446, University, Alabama. *Odonata*.
- '18. Snapp, Oliver I., Box 527, Fort Valley, Georgia. *Rhynchophora*.
- '39. Snipes, Benjamin T., Office of State Entomologist, State Dept. of Agri., Powell, Wyo. *Siphonaptera*.
- '24. SNODGRASS, R. E., 3706 Thirteenth St., N. W., Washington, D. C. (F. '27). *Morphology*.
- '36. Snyder, Fred M., 2015 Jefferson St., Madison 5, Wisconsin. *Muscoidea*.
- '38. Sommerman, Kathryn M., Nat. Hist. Survey, 227 Nat. Resources Bldg., Urbana, Ill. *Corrodentia*.
- '26. Sorenson, Chas. J., Agri. Exp. Sta., Logan, Utah. *Miridae*.
- '43. Sparks, Sue D., see Mrs. W. M. Lewis.
- '14. \*Spencer, G. J., Univ. Brit. Col., Vancouver, Brit. Col., Canada. *Trypetidae*.
- '19. SPENCER, LT. COL. HERBERT, Monticello Hotel Apts., A-3, Charlottesville, Va. (F. '37). *Hymenoptera*.
- Ch. SPOONER, CHAS. S., 1436 Seventh St., Charleston, Ill. (F. '43). *Fulgoridae*.
- '29. Spruijt, F. J., 3248 "O" St., N. W., Washington, 7, D. C. *Formicidae*.
- '39. Stafford, Eugene M., Rt. 8, Box 721, Fresno, Calif. *Vegatable Insects*.
- '10. STAFFORD, E. W., State College, Miss. (F. '43). *Mallophaga*.
- '38. Stains, George S., care of Geo. F. Knowlton, Dept. Ent., Utah Agri. College, Logan, Utah. *Conopidae, Simuliidae*.
- '30. Stanford, J. S., Agri. College, Logan, Utah. *Siphonaptera*.
- '30. Stanley, W. W., Agri. Exp. Sta., Knoxville, Tenn. *Phalaenidae*.
- '35. Stehr, William C., Dept. of Biology, Ohio Univ., Athens, Ohio. *Coccinellidae, Carabidae*.
- '38. Steiner, Harold M., Box 123, Arendtsville, Pa. *Fruit Insects*.
- '27. Steiner, L. F., 1237 Washington Ave., Vincennes, Indiana. *Fruit Insects*.
- '29. Steinweden, John B., Bur. Nursery Service, State Dept. Agriculture, Sacramento, Calif. *Coccidae, Thysanoptera*.
- '31. STEWART, M. A., Div. of Ent. & Parasitology, 112 Agri. Hall, Univ. of Calif., Berkeley 4, Calif. (F. '41). *Siphonaptera*.
- '15. Stiles, Chas. F., Box 29, Stillwater, Okla.
- '38. Stitt, Loyd L., Dept. Zool. & Ent., Iowa State Coll., Ames, Iowa. *Miridae*.

- '27. STONE, ALAN, Bureau Entomology and Plant Quar., Washington 25, D. C. (F. '40). *Simuliidae, Tabanidae*.
- '36. Stone, Philip C., Dept. of Entomology, Univ. of Missouri, Columbia, Mo. *Ixodidae*.
- '28. Stone, Wm. E., Laboratorio Entomologico, Apartado Num. 3, Colonia Anahuac, D. F., Mexico.
- '42. Strandtmann, R. W., Dept. Preventive Medicine, Med. Branch, Univ. of Tex. Galveston, Texas.
- '12. Strickland, E. H., Main Library, Univ. of Alberta, Edmonton, Alberta, Canada. *Elateridae*.
- '25. Strohecker, H. F., Dept. Biology, Kenyon College, Gambier, Ohio.
- '34. Strom, Lawrence G., 604 A. South 28th St., Milwaukee, Wis. *Aphidae*.
- '31. Summerour, A. R., Box 173, Lucedale, Miss.
- '23. SWEETMAN, HARVEY L., State College, Amherst, Mass. (F. '43). *Ecology*.
- '20. SWEZEY, OTTO H., 2044 Lanihuli Drive, Honolulu 5, Hawaii. (F. '30). *Delphacodae*.

## T

- '37. Talbot, Mary, Lindenwood College, St. Charles, Missouri. *Formicidae*.
- '36. Tanner, M. C., 2902 Jackson Ave., Ogden, Utah. *Plecoptera*.
- '27. Tanner, Vasco M., Brigham Young Univ., Provo, Utah. *Tenebrionidae, Carabidae*.
- Ch. Tanquary, M. C., Univ. Farm, St. Paul, Minn. *Apiculture*.
- '40. Tarshis, Irvin, 1032 N. W. 14th Ave., Portland 9, Oregon.
- '31. Tate, H. D., Dept. of Ent., College of Agriculture, Lincoln, Neb. *Ixodidae*.
- '36. \*Tauber, Oscar E., Zool. Dept., Iowa State College, Ames, Iowa. *Physiology*.
- '22. Taylor, Leland H., Dept. Botany & Zool., W. Va. Univ., Morgantown, W. Va. *Bees, Wasps*.
- '29. Taylor, R. L., 627 Powell St., Williamsburg, Va. *Parasitic Hymenoptera*.
- '34. \*Telford, Horace S., Research Labs., Dr. Hess & Clark, Inc., Ashland, Ohio. *Syrphidae*.
- '40. Thatcher, Capt. Theodore O., care of J. Karl Wood, River Heights, Logan, Utah. *Scolytidae, Buprestidae, Cerambycidae*.
- '21. Thomas, Chas. A., 120 S. Broad St., Kennett Square, Chester County, Pa. *Elateridae, Scarabaeidae*.
- '32. Thomas, Edward S., Ohio State Museum, Ohio St. Univ., Columbus 10, Ohio. *Orthoptera*.
- '38. Thomas, Henry D., North Park College, Foster & Kedzie, Chicago 25, Ill.
- '15. Thomas, F. L., College Station, Texas. *Cotton Insects*.
- '39. Thompson, W. L., Box 1074, Lake Alfred, Fla. *Citrus Insects*.
- '10. THOMPSON, W. R., 228 Dundas St., Belleville, Ontario, Canada. (F. '27). *Tachinidae*.
- '22. Tietz, Harrison M., Dept. Zool., Pa. St. Coll., State College, Pa. *Noctuidae*.
- '11. TIMBERLAKE, P. H., Citrus Exp. Sta., Riverside, Calif. (F. '38). *Encyrtidae*.
- '23. Tissot, A. N., Agr. Exp. Station, Gainesville, Fla. *Aphididae*.
- '26. Todd, F. E., care of Bee Culture, Beltsville, Md. *Apiculture*.
- '33. Tongyai, M. R. Chakratong, Dept. of Agriculture, Bangkok, Thailand. *Buprestidae*.
- '29. Tosawa, Nobuyoshi, Kotoen, near Nishinomiya, Hyogo-ken, Japan. *Hymenoptera*.
- '33. TOWNES, HENRY K., JR., 24 Lincoln Ave., Takoma Park, Md. (F. '43). *Ichneumonidae, Chironomus*.
- '28. Townsend, Lee H., Dept. Ent., Univ. of Kentucky, Lexington, Ky. *Neuroptera*.
- '36. Trager, Lt. Wm., Camp Hdq., 6th Army Training Center, A. P. O. 926, care of Postmaster, San Francisco, Calif. *Insect Nutrition*.
- '39. Traub, Lt. Robert, care of Dept. Ent., Univ. of Ill., Urbana, Ill. *Siphonaptera*.
- '30. TRAYER, (MISS) JAY R., Fernald Hall, Mass. State College, Amherst, Mass. (F. '35). *Ephemeroidea*.
- '30. Travis, Bernard V., Box 3391, Orlando, Fla. *Culicidae*.
- '39. Trembley, Helen L., National Institute of Health, Bethesda, Md.

- '34. Trippel, A. W., Indiana Dept. of Conservation, Box 408, Auburn, Indiana. *Chrysomelidae*.  
 '38. Tuck, Lt. Joseph B., 1110 Kearney St., Manhattan, Kansas. *Orthoptera*.  
 '08. Turner, Wm. F., 310 Woodward Ave., Chattanooga, Tenn.  
 '29. \*TUTHILL, L. D., Dept. of Ent., Ia. St. College, Ames, Ia. (F. '43). *Psyllidae*, *Fulgoridae*.

## U

- '39. Uchida, T., Entomological Institute, Hokkaido Imp. Univ., Sapporo, Japan. *Ichneumonidae*.  
 '20. Uichanco, L. B., Agri. College, Laguna, P. Is. *Hemiptera*.  
 '32. USINGER, ROBERT L., 605 Volunteer Bldg., Atlanta, Ga. (F. '41). *Heteroptera*, except *Corixidae*.

## V

- '22. Vance, Arlo M., Box 606, West Lafayette, Ind. *Ecology*.  
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 Ch. VAN DYKE, E. C., Dept. of Entomology, California Acad. Sci., Golden Gate Park, San Francisco, Calif. (F. '17). *Coleoptera*.  
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 '42. Velasco, Vicente, Carrera 9a-No. 4-68, Coli, Colombia.  
 '43. Venard, Carl E., Dept. Zool. & Ent., Ohio State Univ., Columbus 10, Ohio.  
 '37. Viado, Getulio B., Agricultural College, Laguna, P. I. *Toxicology*.  
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## W

- '15. WADE, J. S., Bur. Ent. & Pl. Quar., Washington, D. C. (F. '37). *Coleoptera*.  
 '21. WADLEY, F. M., 3215 N. Albemarle, Arlington, Va. (F. '39). *Aphididae*.  
 '18. Wainwright, C. J., 172 Hamstead Rd., Handsworth, Birmingham, England. *Tachinidae*.  
 '22. Walkden, Herbert H., Bur. Ent. & Pl. Quar., 201 Post Office Bldg., Hutchinson, Kans. *Noctuidae*.  
 '10. WALKER, E. M., Dept. Biol., Univ. Toronto 5, Ontario, Canada. (F. '14). *Odonata*, *Orthoptera*.  
 '30. Walker, Harry G., Va. Truck Exp. Sta., P. O. Box 267, Norfolk, Va. *Economic Entomology*.  
 '38. Wallace, George E., Dept. Ent., Carnegie Museum, Pittsburgh, Pa. *Chalcididae*.  
 '23. Wallace, Hugh E., 210 Santa Rita, Modesto, Calif.  
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 '37. Walter, E. V., Box 495, Lafayette, Indiana. *Economic Entomology*.  
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 Watkins, Thomas C., Comstock Hall, Cornell Univ., Ithaca, N. Y.  
 WATSON, J. R., Agri. Exp. Sta., Univ. Fla., Gainesville, Fla. (F. '39). *Thysanoptera*.  
 '25. Watson, S. A., Wilmington College, Wilmington, Ohio. *Miridae*, *Hemiptera*.  
 '16. Webber, Ray T., 8 Whippany Road, Morristown, N. J. *Tachinidae*.  
 '34. Weber, Neal A., Dept. of Biology, University Station, Grand Forks, N. D. *Formicidae*.  
 Ch. WEBSTER, R. L., Agri. Exp. Sta., Pullman, Washington. (F. '32).  
 Ch. WEED, CLARENCE M., 854 Andover St., Lowell, Mass. (F. '24).  
 '18. Wehrle, L. P., 1130 East Helen St., Tucson, Arizona. *Coccidae*, *Aphididae*.  
 '17. Weigel, C. A., Bur. Ent. and Pl. Quar., Beltsville, Md. *Greenhouse Insects*.  
 '39. Weinman, Carl J., 705 Arlington Court, Champaign, Ill. *Insecticides*.

- '13. WEISS, HARRY B., 19 N. Seventh Ave., New Brunswick, N. J. (F. '37).  
*Ecology.*
- '12. WELCH, P. S., Dept. Zool., University Mich., Ann Arbor, Mich. (F. '20).  
*Aquatic Insects.*
- '07. WELD, LEWIS H., 6613 N. Washington Blvd., East Falls Church, Va. (F. '41).  
*Cynipidae.*
- '21. Wellhouse, Walter H., Dept. Ent., Iowa St. College, Ames, Iowa.
- '36. Wells, R. W., P. O. Box 208, Dallas, Texas. *Gasterophilus, Hypoderma.*
- '39. Wenzel, Rupert L., Field Museum Nat. Hist., Burnham Park, Chicago, Ill.  
*Histeridae.*
- '36. West, A. S., Jr., Dept. of Forest Entomology, University of New Brunswick, Fredericton, New Brunswick, Canada. *Buprestidae.*
- '43. West, Capt. Luther S., Sn. C., Army Medical School, Army Med. Center, Washington 12, D. C.
- '42. Westfall, Minter J., Jr., 321 E. Harvard Ave., Orlando, Fla.
- '41. Weymann, Michael A., 1349 South Ave., Stratford, Conn.
- '39. Whall, Harry H., Mt. Hope Cemetery, Jackson Ave., Hastings-on-Hudson 6, N. Y.
- '18. Whedon, A. D., 1145 Third St. N., Fargo, N. Dakota. *Odonata.*
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*Formicidae, Eucharidae.*
- '32. Whitcomb, W. D., 240 Beaver St., Mass. St. College Exp. Sta., Waltham, Mass.
- '29. Wilbur, D. A., K. S. C., Manhattan, Kansas. *Homoptera, Cicadellidae.*
- '24. WILCOX, JOSEPH, 1208 E. Main, Alhambra, Calif. (F. '41). *Asilidae.*
- '35. Wild, William, 249 Walnut St., East Aurora, N. Y. *Microlepidoptera.*
- '36. Wilkes, A., Dominion Parasite Lab., Belleville, Ontario, Canada.
- '39. Will, Homer C., Juniata College, Huntingdon, Pa. *Tenthredinoidea.*
- '38. Willemsse, C., Eygelshoven, Z. L., Holland. *Orthoptera.*
- '14. WILLIAMS, C. B., Rothamsted Exp. Station, Harpenden, Herts, England. (F. '30). *Migrations of Insects.*
- '38. Williams, J. L., Box 72, Lincoln Univ., Pa. *Lepidoptera.*
- '40. Williams, Ensign Roger W., DeLamar Institute of Public Health, 600 W. 168th St., New York 32, N. Y.
- '23. Wilson, C. C., P. O. Box 1857, Sacramento, Calif. *Orthoptera.*
- '33. Wilson, E. Haven, Bridgton, Maine.
- '25. Wilson, F. H., Dept. Zool., Tulane Univ., New Orleans, La. *Mallophaga.*
- Ch. Wilson, Harley F., Dept. Econ. Ent., King Hall, Univ. of Wisconsin, Madison, Wis. *Aphididae.*
- '30. Wilson, Capt. John W., 7th Malaria Survey Unit, A. P. O. 629, care of Postmaster, New York, N. Y. *Economic Entomology.*
- '28. Windsor, Margaret, 772 Santa Ynez, Stanford Univ., Calif. *Stratiomyidae.*
- '37. Wing, Merle W., Dept. Zool. & Ent., N. C. State College, Raleigh, N. C. *Formicidae.*
- '41. Wirth, Willis W., 545 N. E. 32nd St., Miami, Fla. *Culicidae, Reduviidae.*
- Ch. \*Wirtner, M., St. Vincent Archabbey, Latrobe, Pa. *Hemiptera.*
- '27. Wiscup, C. B., Box 819, Lucerne Ter., Orlando, Fla. *Insecticides.*
- Ch. WOGLUM, R. S., Box 5030 Metropolitan Station, Los Angeles, Calif. (F. '39).
- '31. Woke, Lt. Comdr. P. A., 8240 Northview Road, Watersedge, Dundalk P. O., Baltimore, Md. *Culicidae.*
- '34. Wolfenbarger, D. Otis, Dept. of Entomology, Univ. of Delaware, Newark, Del. *Economic Entomology.*
- '42. Wood, Stephan L., River Heights, Logan, Utah.
- '14. Wood, W. B., 4620 Butterworth Pl., N. W., Washington, D. C.
- '37. Woodbury, Elton N., Naval Stores Dept., Hercules Powder Co., Wilmington, Del. *Insecticides.*
- '25. WOODRUFF, L. C., Dept. Ent., Univ. of Kansas, Lawrence, Kans. (F. '35).  
*Insect Physiology.*
- '22. Worthley, H. N., Chemical Warfare Board, C. W. Center, Edgewood Arsenal, Maryland. *Insecticides.*
- '28. WRAY, DAVID L., JR., Dept. of Agriculture, Raleigh, N. C. (F. '43).
- '39. Wright, Mike, P. O. Box 655, New Smyrna Beach, Fla. *Odonata.*

## Y

- '43. Yergason, Robert M., 50 Farmington Ave., Hartford, Conn.  
'31. YEAGER, J. F., Beltsville Center, Beltsville, Md. (F. '37). *Physiology*.  
'40. Yolles, Tamarath K., Malaria Laboratory, Office of Sector Surgeon, A.P.O.  
868, Postmaster, New York, N. Y. *Culicidae, Ceraatopogonidae*.  
'28. Young, Hiram C., Box 132, Florala, Alabama. *Cotton Insects*.

## Z

- '21. Zerny, Hans, Wien I, Burgring 7, Vienna, Austria. *Heterocera*.  
'07. ZETEK, JAMES, Drawer C, Balboa, Canal Zone. (F. '39). *Trypetidae*.  
'41. \*Zimmerman, Elwood C., Bishop Museum, Honolulu 35, T. H.

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THE LIFE HISTORY OF THE TICK *ORNITHODOROS*  
*CORIACEUS* KOCH (ARGASIDAE)<sup>1</sup>

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Bureau of Entomology and Plant Quarantine<sup>2</sup>

The tick *Ornithodoros coriaceus* was described by Koch (1844) and redescribed by Nuttall, Warburton, Cooper, and Robinson (1908). Herms (1916) has given the distribution in California, where it is known as the pajaroello. It is not known to occur elsewhere in the United States. The distribution in Mexico, where it is known as the tlalaja, has been given by Hoffmann (1930). True (1932) studied the anatomy and histology of the alimentary canal in this species. Most textbooks on medical entomology refer to the severity of its bite.

Herms (1916) published a brief account of the life history of this species. He recorded an incubation period of 21 days at 26° C., a complete developmental cycle (egg to egg) of 15 months, and an individual developmental period (egg to adult) of 159 days for a male and 343 days for a female. He observed one female to lay 10 lots of eggs, as many as 802 eggs in a single lot, and 1,158 eggs in seven lots in a single season, and observed first-stage nymphs to molt without feeding. He did not indicate the extent of his material, but the foregoing specific records were taken from only three individual ticks, a female collected in nature and a male and female reared from eggs. He gave the durations of the larval and nymphal instars for the reared female. In addition, he reported a minimum larval period of 19 days, and stated that four to seven molts occur during development, indicating one larval and three to six nymphal stages.

Since the small number of records on which Herms' paper was

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<sup>1</sup>A portion of a thesis submitted to the Graduate Council of the George Washington University in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

<sup>2</sup>The writer is indebted to various members of the faculty of the George Washington University and to F. C. Bishopp, Assistant Chief of the Bureau of Entomology and Plant Quarantine, for helpful suggestions and criticisms, and to C. B. Othier, of Salinas, Calif., and R. J. O'Bryant and C. S. Robinson, of the Forest Service of the United States Department of Agriculture, Santa Barbara National Forest, for their kindness in submitting living material.



apparently based made additional observations on this species seem desirable, work on its biology was begun when living specimens came to hand.

### THE EGG

The following incubation records were obtained at Washington, D. C., on nine lots of eggs from females engorged in the laboratory: At room temperatures in June, July, and August, 10 days at an average

TABLE I  
ENGORGEMENT OF LARVAE OF *Ornithodoros coriaceus*

DATE PLACED ON HOST	HOST	NUMBER APPLIED	NUMBER OF ENGORGED LARVAE DROPPED ON THE SPECIFIED DAY AFTER ATTACHING																Total
			5	6	7	8	9	10	11	12	13	14	15	16	17	18			
1934																			
Oct. 9. . . . .	Guinea pig. . .	8			2		2											4	
Oct. 23. . . . .	Guinea pig . . .				19	8	8	2										37	
Dec. 11. . . . .	Guinea pig . . .	11			2		2	1										5	
Dec. 14. . . . .	Guinea pig . . .	70			1	4	1	3	6	2	3	2						22	
1935																			
Jan. 22. . . . .	Guinea pig . . .	38					4		2	1	3							10	
July 19. . . . .	Guinea pig. . .	50					2	6	8		4		4					24	
Aug. 19. . . . .	Rabbit . . . . .	60					9	5	10	3								27	
Aug. 20. . . . .	Rabbit . . . . .	63				30	19	12										61	
Aug. 20. . . . .	Rabbit . . . . .	72				14	14	11	2									41	
Sept. 8. . . . .	Rabbit . . . . .	150						9	4	26	5	30	21	15				110	
Sept. 8. . . . .	Rabbit. . . . .	150								4	7	1	6	1				19	
Sept. 8. . . . .	Rabbit . . . . .	150			1	4	37	5	33	3	15	1	6					105	
Sept. 27. . . . .	White rat . . .	10																0	
1938																			
May 30 . . . . .	Rabbit . . . . .	329	6	43	79	68	39	21	8									264	
1940																			
Mar. 20 . . . . .	Rabbit . . . . .	527		13	12	6	1		1	3	1		2	1		1		41	
Total . . . . .		1,688	6	56	160	138	133	58	82	27	50	34	24	1		1		770	

temperature of 86.2° F., 10 days at 83.0°, 11 days at 84.5°, 13 days at 83.4°, and 15 days at 79.7°; at heated room temperatures in January and February, 19 days at an average temperature of 78.4°, 20 days at 78.4°, and 20 days at 78.3°; at incubator temperatures of 80° and 90° in December, 10 days. Eleven other lots on which the records were not exact to the day fell within this range, but one lot kept in a heated room in November and December showed an incubation period of 23 to 29 days.

### THE LARVA

Observations were made on 22 lots of larvae kept in glass vials at various temperatures. Unfed larvae were short lived, all individuals in some lots dying within two months and none living longer than five months. They were able to engorge satisfactorily when as much as 63 days old, and fed readily on guinea pigs and rabbits, but not on a white rat. Engorgement records on 770 individuals are presented in Table I. The larvae remain attached to the host for several days, the

average time required for those tabulated being 9.2 days, with the greatest number dropping on the seventh day. A few completed engorgement in five days, and one remained attached for 18 days. The measurements of 22 fully engorged larvae in the antero-posterior, lateral, and dorso-ventral dimensions, respectively, ranged from 3.2

TABLE II

RECORD OF LARVAE OF *Ornithodoros coriaceus* MOLTING TO FIRST-STAGE NYMPHS

DATE DROPPED	NUMBER OF LARVAE	NUMBER OF LARVAE THAT MOLTED ON THE SPECIFIED DAY AFTER DROPPING																						Total
		4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22				
1934																								
Oct. 18....	2					1																1		
Oct. 30....	7 <sup>3</sup>		2																			2		
Oct. 31....	4								2													2		
Oct. 31....	4 <sup>3</sup>	3																				3		
Nov. 1....	4 <sup>3</sup>	2																				2		
Nov. 1....	4										3					1						4		
Nov. 2....	2								2													2		
Dec. 18....	2 <sup>3</sup>	1	1																			2		
Dec. 22....	4 <sup>3</sup>	1	2	1																		4		
Dec. 23....	1 <sup>3</sup>		1																			1		
Dec. 24....	2 <sup>3</sup>	1																				1		
Dec. 25....	6 <sup>3</sup>			5						1												6		
Dec. 26....	2 <sup>3</sup>	2																				2		
Dec. 27....	3 <sup>3</sup>	1	2																			3		
Dec. 28....	1 <sup>3</sup>			1																		1		
1935																								
Feb. 1....	2			2																		2		
Feb. 2....	1		1																			1		
Aug. 27....	53					7	16	10	6	2	5	3	2	1	1							53		
Aug. 28....	38					1	7	16	2	6	4	1							1			38		
Aug. 29....	33				2	1	1	2	14	2	2	2	2	1			1		2			32		
Aug. 30....	5								1	1	3											5		
1938																								
June 4....	21									6	10	3	1									20		
June 5....	64								12	31	5	7	1									56		
June 6....	98							4	40	17	17	1										79		
June 7....	80					2	1	13	21	32	2	1										72		
June 8....	52							3	31	6	1											41		
June 9....	33					2	6	10	5	2												25		
June 10....	12						1	6	5													12		
July 5....	32			1	17	8	3															29		
July 6....	82			1	13	33	6	3	5													61		
July 7....	54				1	1	6	1	6	1												16		
July 8....	23			1	1	1	3	2	1													9		
July 9....	15					1	1	4	1													7		
Total...	746	11	8	13	35	58	54	71	153	107	52	18	6	2	1	1	1		2	1		594		

<sup>3</sup>Kept in incubator at 81-90° F. All other lots kept at room temperature, heated in winter.

by 2.0 by 1.5 mm. to 4.3 by 3.0 by 2.0 mm., the average being 4.1 by 2.6 by 1.7 mm.

A few days after engorging, the larvae molt to nymphs, the time required for this change being influenced to a considerable extent by the temperature. Molting records on 594 larvae are presented in Table II.

Some individuals kept at the higher temperatures molted within four days after dropping from the host, while one at normal August and September temperatures required 22 days. The molting of a single lot of 33 larvae, all dropped on the same day and kept under the same conditions of temperature and humidity, was spread over 15 days, two individuals molting as early as the seventh day and two as late as the twenty-first. It will be noted that this is a much greater variation than that between the first moltings in lots kept at different temperatures. The greatest number of larvae molted on the eleventh day, and the average for the 594 was 10.7 days.

### THE FIRST-STAGE NYMPH

In common with the other species of its genus, *Ornithodoros coriaceus* goes through several nymphal stages, feeding and molting repeatedly before becoming adult. The number of nymphal stages was found to range from three to seven, one more than required by Herms.

Nymphs in the first stage ordinarily do not feed, but molt to the second stage without engorgement. There is accordingly no increase in size in this stage. Daily molting records were obtained from nymphs kept in pill boxes on dry or moist sand, at room temperature or in an incubator at 81 to 90° F. The molting period of nine nymphs at the incubator temperature ranged from 11 to 27 days, with an average of 15.9 days. The molting period of 125 nymphs at heated room temperature from September to February ranged from 18 to 151 days, with an average of 37.9 days. The molting period ranged from 18 to 19 days for eight nymphs, from 20 to 29 days for 66 nymphs, from 30 to 39 days for 33 nymphs, from 40 to 49 days for four nymphs, and from 108 to 151 days for 14 nymphs.

No nymphs molted between the 49th and 108th days. A typical lot of 11 specimens spread over almost the entire range, their individual molting periods being 18, 19, 27, 27, 28, 28, 28, 30, 30, 31, and 120 days, respectively, although all were kept under identical conditions of temperature and humidity.

On 32 occasions one or more nymphs that were two to eight months old and had not yet molted were placed on hosts, to see if these stragglers would take a meal to hasten development. Three specimens attached, but only two became fully engorged, one requiring 70 and the other 80 minutes. Both were about four months old at the time of feeding. One molted 25 days later and the other 43 days later.

### THE SECOND-STAGE NYMPH

The second-stage nymphs invariably feed before molting, but remain attached to the host for a comparatively short time. In these studies they were fed on rabbits and guinea pigs, to which they usually attached readily. Some individuals, however, went through long periods of fasting, during which they repeatedly refused a host, before they were finally ready to engorge. Fasting, engorgement, molting, and other records were obtained on 137 individuals by daily observations. Selected typical and extreme records are presented in Table III, but in the following discussion the records of all 137 are summarized.

Forty-three individuals, or 31 per cent of the entire number, consistently refused to feed until the time of their death, one of them rejecting five opportunities over a period of 314 days. Thirty-two individuals, or 23 per cent, refused to feed one, two, three, or four times

TABLE III  
ENGORGEMENT, MOLTING, AND LONGEVITY OF SECOND-STAGE NYMPHS OF  
*Ornithodoros coriaceus*

Molted From 1st Stage	Refused to Feed	Engorged	Molted to 3rd Stage	Noted Dead	Period From Feeding to Molting (Days)	Duration of Stage (Days)	Feeding Period (Min.)	Size when Engorged (mm.)
11-17-34 <sup>4</sup>		12-6-34	1 15-35		40	59	20	.
1- 3-35	5-21-35	6- 3-35	6-27-35		24	175	19	..
1-17-35 <sup>4</sup>		6- 3-35	6-19-35		16	153	30	.
1-22-35	8-21-35	5-21-35		12- 5-35		211 <sup>6</sup>	32	..
1-22-35		5-21-35	9-20-35		122		66 <sup>6</sup>	
		8-21-35			30	241	91 <sup>5</sup>	4.9 x 2.9 x 2.1
1-26-35 <sup>4</sup>		5-21-35	6- 5-35		15	130	19 <sup>5</sup>	.
9 21-35	12-3-35			2-17-36		73 <sup>6</sup>		.
9-22-35	10 25-35, 11-20-35,							
	12-9-35	2-17-36	3-14-36		26	174	61 <sup>5</sup>	.
9-22-35	10-25-35, 11 20-35	12- 9 35	1- 4-36		26	104	68 <sup>5</sup>	.
9-23-35	10-25-35, 11-20-35,			8- 5-36		177 <sup>6</sup>	20	
	12-9 35, 2-17 36	3-18-36			72		33	4.8 x 2.9 x 2.3
9 24-35	11 20 35	12- 9 35	1 5-36		27	103	129 <sup>5</sup>	.
9-25 35	10-25-35, 11-20-35	12- 9 35	12-28-35		19	94	122 <sup>5</sup>	.
9-25-35	11-20-35, 8-5-36			11-12-36		315 <sup>5</sup>		.
9-26-35	10-25-35, 11-20 35,							
	2-17-36, 3-18-36,			11-12-36		314 <sup>6</sup>		.
	8-5-36							
9 29-35	11-20-35	3-18-36	7- 2-36		106	277	15	
10- 1-35	11-20-35			8- 5-36		50 <sup>6</sup>		
10- 2-35		12- 2-35	1- 3-36		32	93	30	6.8 x 4.0 x 3.4
10- 3-35		12 3-35	1- 2-36		30	91	24	6.6 x 4.0 x 3.0
10- 3-35	12-3-35	7 29-36	9-11-36		44	344	22	6.0 x 3.9 x 3.4
10- 5-35		12- 3-35		7-26-36		59 <sup>6</sup>	17	6.5 x 3.9 x 3.0
10- 6-35	12-3-35	7-29-36	8-24-36		26	323	42	5.6 x 3.5 x 3.2
10- 9-35	12-3-35, 2-17-36	7-29-36	10- 9-36		72	366	30	5.4 x 3.2 x 2.8
10- 9-35		12- 3-35	1- 6-36		34	89	63 <sup>5</sup>	7.1 x 4.2 x 3.3
10-10-35	12-3-35	2-17-36	3-23-36		35	165	22	6.3 x 3.8 x 3.1
10-15-35	12-5-35; 2-17 36.	7-29-36	9- 1-36		34	322	47	4.9 x 3.0 x 2.5
10-22-35		12 5-35	1- 7-36		33	77	68 <sup>5</sup>	6.4 x 3.9 x 3.0
10-29-35		12- 5-35	1 13-36		39	76	57 <sup>5</sup>	6.5 x 3.6 x 3.0
12-29-35	2-17-36, 3-18-36,	7-29-36	10-14-36		77	290	23	5.9 x 4.8 x 3.0
1- 2-36	3-18-36	7-29-36	9-16-36		49	258	30	6.2 x 3.7 x 3.2
		3-26-36			149		103 <sup>6</sup>	
1-21-36		7-27-36	8-22-36		26	214	16	..

<sup>4</sup>Kept in cabinet at 81-90° F., all others kept at room temperature, heated in winter.

<sup>5</sup>Picked from host.

<sup>6</sup>At least this long, see text.

before they finally accepted a meal when placed on a host. Thirty of those that had refused to feed one or more times before engorging molted successfully, only two dying before reaching the third stage, showing that refusal of a host did not indicate an abnormality. Three of the 62 that engorged at the first opportunity died before molting.

Eighty-five specimens engorged only once, and three engorged twice, before molting to the next stage. Hosts were accepted in from 19 to 301 days after the tick had molted from the previous stage. The ticks became fully engorged and dropped in from 8 to 155 minutes. Many specimens became fully engorged in a short time but instead of dropping at once remained attached to the host and began to secrete coxal fluid and to lose size. When it became apparent that these had completed feeding but would not or could not drop normally, they were picked off, as indicated in the table. The size of 29 second-stage nymphs when fully engorged ranged from 7.1 by 4.2 by 3.3 mm. to 4.8 by 2.9 by 2.3 mm., with an average of 5.9 by 3.6 by 2.9 mm.

Among ticks that fed only once, molting to the third nymphal stage occurred in from 15 to 106 days after feeding. One of the ticks that fed twice did not molt for 149 days after the first meal and 26 days after the second.

The total duration of the second nymphal stage, in individuals that molted, ranged from 59 to 366 days. As the ticks that fail to molt approach death they become sluggish and are difficult to stimulate, so that it is almost impossible to determine whether they are actually dead until they become dry and brittle. For this reason, in this and the following tables, the date under "Noted dead" is well after death actually occurred, and records of the time spent in the stage are therefore calculated from the last living observation as noted in the second or third column. Estimated by this method, the duration of the second stage of ticks that did not feed ranged from over 50 to over 315 days, whereas that of ticks that fed but did not molt ranged from over 59 to over 211 days.

### THE THIRD-STAGE NYMPH

The behavior of the third-stage nymphs is very similar to that of nymphs in the second stage with respect to the feeding period, refusal of hosts, longevity, and molting. Records were obtained on 80 individuals by daily observation. Selected typical and extreme examples are presented in Table IV, but in the following discussion the records of all 80 are summarized. Twenty-five individuals, or 31 per cent, consistently refused to feed throughout their lives, rejecting from one to five opportunities over periods of as much as 340 days. Eighteen individuals, or 23 per cent, refused to feed once or twice before taking a host. One of these refused to feed nine times, but engorged twice, during a period of three years and 11 months, after which it died without molting. Thirty-seven ticks, or 46 per cent, engorged at the first opportunity.

Engorgement occurred satisfactorily when nymphs had been in the third stage for as short a time as nine days, and as long as two years, but the individual making the latter record did not molt. Two individuals that engorged one year and six weeks after molting from second-stage nymphs molted successfully to the next stage. Most of the nymphs would accept only one meal, but some fed two or three times. Complete engorgement and dropping from the host required from 5 to 62 minutes, but some individuals did not drop and had to be picked off. Measurements of 37 nymphs fully engorged ranged

from 6.5 by 4.0 by 3.0 mm. to 9.9 by 6.4 by 5.1 mm., with an average of 7.8 by 4.8 by 3.9 mm. Only one of the specimens that fed more

TABLE IV  
ENGORGEMENT, MOLTING, AND LONGEVITY OF THIRD-STAGE NYMPHS OF  
*Ornithodoros coriaceus*

Molted From 2nd Stage	Refused to Feed	Engorged	Molted to 4th Stage or Adult	Noted Dead	Period From Feeding to Molting (Days)	Duration of Stage (Days)	Feeding Period (Min.)	Size when Engorged (mm.)
12-31-34 <sup>7</sup>		5-21-35	6-6-35	..	16	157	60 <sup>8</sup>	..
6-17-35	8-21-35	10-25-35	..	..	101	..	100 <sup>8</sup>	..
		12-9-35	2-3-36	..	56	231	24	..
6-27-35	8-21-35	7-6-35	8-26-35	..	51	60	19	..
12-28-35		2-17-36	3-26-36	..	38	89	40	9.5 x 5.9 x 5.1
12-30-35	2-17-36	3-18-36	5-18-36	..	61	140	62	7.1 x 4.5 x 3.7
12-31-35	3-18-36	7-29-36	9-16-36 <sup>9</sup>	..	49	260	13	8.4 x 5.2 x 4.3
1-1-36	3-18-36			7-29-36		77		..
1-2-36	3-18-36; 7-29-36;							..
	12-7-36			1-10-37		340		..
1-5-36	3-26-36; 1-7-37;	7-27-36			270		24	8.4 x 5.0 x 4.3
	4-6-37	12-3-36			141		17	..
		2-23-37	4-23-37 <sup>9</sup>		59	474	13	..
1-5-36	3-26-36; 7-27-36..	12-7-36	1-7-37		31	368	22	7.6 x 3.7 x 3.0
1-5-36		3-26-36	6-4-36		70	151	14	8.0 x 5.0 x 4.2
1-6-36	3-26-36	7-27-36	9-11-36 <sup>9</sup>		46	249	21	9.9 x 6.4 x 5.1
		3-26-36			185		23	9.2 x 5.7 x 4.5
1-7-36		7-27-36	9-27-36		62	264	19	8.8 x 5.4 x 4.9
1-8-36	3-26-36	7-27-36	9-16-36 <sup>9</sup>		51	252	30	8.1 x 5.1 x 4.0
1-9-36	7-27-36	3-26-36	8-10-36		137	214	23	8.9 x 5.8 x 4.5
1-15-36		3-26-36	5-8-36		43	114	10	6.5 x 4.0 x 3.0
1-21-36		3-26-36	4-20-36		25	90	17	8.0 x 5.2 x 4.1
	12-3-36; 1-10-37							..
1-31-36	2-23-37; 5-31-37	8-6-36					28	..
	11-26-37; 1-30-40	2-15-38		4-18-40		1,460	8	..
2-23-36	8-6-36; 12-7-36;	1-10-37			120		14	7.2 x 4.6 x 3.9
	1-23-37	4-6-37	5-10-37 <sup>9</sup>		34	442	15	..
4-26-36		8-6-36	9-11-36 <sup>9</sup>		36	138	28	..
	5-6-36; 11-22-36	1-7-37					27	..
	2-23-37; 4-6-37;							..
5-13-36	5-31-37; 11-26-37	2-15-38					11	..
	9-15-39, 1-30-40;							..
	4-19-40			6-24-40		1,437		..
6-6-36		8-10-36	9-18-36		39	104	5	7.5 x 4.7 x 3.7
8-24-36		11-22-36			74		14	7.5 x 4.6 x 3.7
		1-7-37	2-4-37		28	164	7	8.0 x 4.4 x 3.4
	11-22-36; 1-10-37;							..
9-11-36	2-23-37; 4-6-37;			11-26-37		262		..
	5-31-37			1-7-37		44		..
10-9-36	11-22-36							..

<sup>7</sup>Kept in cabinet at 81-90° F., all others kept at room temperature, heated in winter.

<sup>8</sup>Picked from host. <sup>9</sup> Molted to male. <sup>9</sup> Molted to female.

than once was measured after each meal, and it was smaller after the second feeding.

Molting occurred as soon as 16 days and as late as 137 days after feeding in the case of ticks that fed only once and as long as 270 days after the first meal in the case of one individual that engorged three

times. Of the 52 specimens that molted, 42 produced fourth-stage nymphs, eight produced males, and two produced females.

The total duration of the third nymphal stage in specimens that molted ranged from 60 to 474 days. The time spent in the third stage by specimens that never fed ranged from about 44 days to more than 340 days and that of specimens that fed one or more times but never molted reached a maximum of more than four years.

#### THE FOURTH-STAGE NYMPH

The behavior of fourth-stage nymphs was similar, in all respects, to that of nymphs in the third stage. Records were obtained on 42 individuals by daily observations. Selected typical and extreme examples are presented in Table V, but in the following discussion the records of all 42 are summarized. Fourteen individuals never fed, refusing from one to eight opportunities to attach during periods of as long as 23 months. Eleven specimens refused to feed one to five times before engorging, and 17 fed at the first opportunity.

Engorgement occurred as soon as 14 days and as late as five years and five months after the nymph had molted from the previous stage. Nymphs that molted to the next stage engorged from one to three times. One tick which was still alive at the time of writing had engorged six times. Complete engorgement required from 7 to 43 minutes of feeding. The size of 17 fourth-stage nymphs when fully engorged ranged from 6.1 to 4.0 by 3.5 mm. to 12.8 by 7.9 by 6.5 mm., with an average of 9.0 by 5.7 by 4.5 mm.

Molting occurred in 19 to 131 days after engorgement, 13 specimens molting to fifth-stage nymphs, two molting to males, and seven molting to females.

The total duration of the stage in the case of those that molted ranged from 39 days to 16 months. The time spent in the stage by ticks that never fed ranged from about 46 days to more than 23 months. Ticks that fed but did not molt lived as long as five years and five months.

#### NYMPHS OF THE FIFTH, SIXTH, AND SEVENTH STAGES

The behavior of nymphs in the fifth, sixth, and seventh stages was similar, in all respects, to that of nymphs in the fourth stage. Records on nymphs in these stages are presented in Table VI. Three of the 13 fifth-stage nymphs and 2 of the 4 sixth-stage nymphs consistently refused to feed during the course of from 3 to 26 months. One fifth-stage nymph fed three times in five years and five months and was still alive and unmolted at the time of writing.

All other nymphs engorged once and molted successfully. The size of four fifth-stage nymphs when fully engorged ranged from 7.9 by 4.9 by 3.4 mm. to 11.9 by 7.9 by 5.9 mm., with an average of 9.5 by 6.1 by 4.5 mm. The size of one sixth-stage nymph was 9.0 by 6.0 by 4.2 mm. and that of one seventh-stage nymph was 10.6 by 6.5 by 5.3 mm.

The period from last feeding to molting ranged from 27 to 110 days in the fifth stage, the nine nymphs that molted producing four nymphs, two males, and three females. Two sixth-stage nymphs molted in 44 days and 72 to 89 days, respectively, after feeding, producing one

nymph and one female. The seventh-stage nymph molted in 45 days to a female.

TABLE V  
ENGORGEMENT, MOLTING, AND LONGEVITY OF FOURTH-STAGE NYMPHS OF  
*Ornithodoros coriaceus*

Molted From 3rd Stage	Refused to Feed	Engorged	Molted to 5th Stage or Adult	Noted Dead	Period From Feeding to Molting (Days)	Duration of Stage (Days)	Feeding Period (Min.)	Size when Engorged (mm.)
6- 6-35 <sup>9</sup>		6-26-35	7-15-35		19	39	43	
6-24-35	8-21-35	7- 8-35	8-24-35		47	61	41	
7-14-35 <sup>9</sup>		8-21-35	9-11-35		21	59	22	61 x 4.0 x 3.5
8-26-35	10-25-35; 12-9-35			8- 5-36		105 <sup>11</sup>		
10-20-35	12-5-35			2-17-36		46 <sup>12</sup>		
12-27-35		2-17-36	3-14-36		26	78	18	
1- 4-36		3-18-36	7-27-36		131	205	28	7.9 x 5.4 x 4.0
		12- 7-36			112		16	
1-10-36	3-26-36, 7-27-36	1-10-37			78		5 <sup>10</sup>	
		2-23-37	3-29-37		34	444		
2-10-36	8-6-36; 12-7-36			1-10-37		301 <sup>12</sup>		
3-26-36	8-6-36, 12-3-36; 1-10-37, 2-23-37, 4-6-37, 5-31-37, 11-26-37, 2-15-38			5-19-38		691 <sup>12</sup>		
4-20-36		8- 6-36	9- 8-36 ♀		33	141	39	11.9 x 7.6 x 6.3
4-22-36	8-6-36; 12-3-36, 1-10-37; 4-6-37..	2-23-37	4-30-37		66	373	15	8.5 x 5.7 x 4.4
4-26-36		8-6-36	9-12-36 ♀		37	139	34	12.5 x 8.0 x 6.4
5- 8-36		8- 6-36	9-16-36 ♀		41	131	30	9.3 x 5.6 x 4.7
		8- 6-36					17	8.3 x 5.2 x 3.8
5-11-36	1-10-37, 2-23-37; 5-31-37, 11-26-37, 9-15-39, 4-19-40	11-22-36 4- 6-37 2-15-38 1-30-40 10-17-41				1,988 <sup>11</sup>	5 <sup>10</sup> 15 8	
5-13-36		8-6-36	9- 8-36 ♀		33	118	7	
5-19-36	11-22-36, 2-23-37; 5-1-37; 11-26-37, 2-15-38	8-10-36 1-10-37 4- 6-37		10-19-39		637 <sup>12</sup>	27 16 7	12.8 x 7.9 x 6.5 7.5 x 4.5 x 3.2 7.5 x 4.3 x 3.2
5-25-36		8-10-36	9-13-36		34	111	32	9.4 x 5.8 x 4.7
7- 5-36		8-10-36	9-17-36 ♀		38	74	23	9.5 x 6.0 x 4.8
8-10-36	11-22-36, 1-7-37, 2-23-37; 4-6-37, 5-31-37	2-15-38		5-19-38		554 <sup>12</sup>	14	
9-18-36	1-7-37; 2-23-37..	11-22-36	3-20-37		118	183	21	9.0 x 5.6 x 4.0
9-29-36	11-22-36			1- 7-37		54 <sup>12</sup>		
10- 7-36	11-22-36; 1-7-37; 2-23-37; 4-6-37..			5-31-37		181 <sup>12</sup>		
1- 7-37	5-31-37, 11-26-37	2-15-38	5-19-38 ♂ <sup>10</sup>		93	497	33	
2- 1-37		5-31-37	7-11-37 ♂ <sup>10</sup>		41	160	22	

<sup>9</sup>Kept in cabinet at 81-90° F., all others kept at room temperature, heated in winter.

♂ Molted to male. ♀ Molted to female.

<sup>10</sup>Incompletely engorged.

<sup>11</sup>Alive October 20, 1941.

<sup>12</sup>At least this long.

The duration of the fifth, sixth, and seventh stages in the case of ticks that molted was 64 to 401 days, 139 to 265 days, and about 100



days, respectively. The known longevity of unfed ticks was 83, 218, and 781 days in the fifth stage and 79 to 81 days in the sixth. A fifth-stage nymph which fed but did not molt was still alive at the time of writing, after 1,911 days.

TABLE VI

ENGORGEMENT, MOLTING, AND LONGEVITY OF FIFTH-, SIXTH-, AND SEVENTH-STAGE NYMPHS OF *Ornithodoros coriaceus*

Molted From Former Stage	Refused to Feed	Engorged	Molted to Next Stage	Noted Dead	Period From Feeding to Molting (Days)	Duration of Stage (Days)	Feeding Period (Min.)	Size when Engorged (mm.)
FIFTH-STAGE NYMPHS								
7-15-35 <sup>13</sup>	..	8-21-35	9-17-35	..	27	64	120 <sup>14</sup>	7.9 x 4.9 x 3.4
8-24-35	10-25-35..	12- 9-35	1-19-36	..	41	148	13	..
9-11-35 <sup>13</sup>	10-25-35.....	12- 5-35	1- 2-36	..	28	113	10	..
9-13-35 <sup>13</sup>	10-25-35; 12-5-35	..	..	8-10-36	..	83	..	..
3-14-36	..	8- 6-36	9-16-36 <sup>15</sup>	..	41	186	23	..
..	(11-22-36; 1-10-37	8-10-36	..	..	..	..	37	8.0 x 4.8 x 3.5
..	2-23-37; 4-6-37	2-15-38	..	..	..	..	22	..
7-27-36	5-31-37; 11-26-37	1-30-40	..	..	..	..	..	..
..	9-15-39; 4-19-40;	..	..	..	..	..	..	..
..	10-17-41..	..	..	..	..	1,911 <sup>15</sup>	..	..
9-13-36	11-22-36; 1-7-37..	2-23-37	4- 3-37 ♀	..	39	202	12	10.0 x 6.8 x 5.3
2-25-37	..	5-31-37	7-13-37 ♀	..	43	138	26	..
3-29-37	..	5-31-37	7-21..	..	..	..	..	..
..	..	..	11-26-37 ♂	..	51-179	114-242	82 <sup>14</sup>	..
4- 3-37	..	5-31-37	7-21..	..	..	..	..	..
..	..	..	11-26-37	..	51-179	109-237	37	11.9 x 7.9 x 5.9
4-30-37	5-31-37; 11-26-37	2-15-38	6- 5-38 ♀	..	110	401	30	..
7-12-37	11-26-37; 2-15-38	..	..	10-19-39	..	218 <sup>16</sup>	..	..
2-24-38	1-30-40; 4-15-40..	..	..	6-24-40	..	781 <sup>16</sup>	..	..
SIXTH-STAGE NYMPHS								
9-17-35 <sup>13</sup>	10-25-35; 12-5-35	..	8-10-36	8-10-36	..	79 <sup>16</sup>	..	..
1- 2-36	..	..	9-23-36 ♀	..	44	265	19	..
1-19-36	..	3-26-36	6-6-23-36	..	72-89	139-156	40	9.0 x 6.0 x 4.2
7-21-	..	..	..	..	..	..	..	..
11-26-37	11-26-37; 2-15-38	..	..	10-19-39	..	81 <sup>16</sup>	..	..
SEVENTH-STAGE NYMPH								
6- 6-23-36	..	8-10-36	9-24-36 ♀	..	45	93-110	36	10.6 x 6.5 x 5.3

<sup>13</sup>Kept in cabinet at 81-90° F., all others kept at room temperature, heated in winter.

<sup>14</sup>Picked from host. ♂ Molted to male. ♀ Molted to female.

<sup>15</sup>Alive October 20, 1941.

<sup>16</sup>At least this long.

## THE ADULT

Records were obtained on the feeding, mating, oviposition, and longevity of 4 males and 17 females collected in nature and of 18 males and 14 females reared from nymphs. Although the records were kept on each tick as an individual, a female might be placed with several males in succession, or vice versa. These records are not adaptable to tabular presentation, but will be briefly discussed.

slightly beyond tip of abdomen; first vein bare, third with 4 setulae near base; first posterior cell nearly closed at costa well before wing tip; last section of fifth vein short; costal spine longer than small cross vein; epaulets blackish. Length, 6.5 mm.

The new species here described agree closely with most of the items mentioned above. The principal distinguishing characters given under the descriptions are listed for ready reference in the following key. Unless otherwise indicated, types of the new species are in my collection.

#### KEY TO SPECIES OF MUSCOPTERYX

1. Abdomen largely gray pollinose and usually densely so . . . . . 3  
    Abdomen shining black with silvery pollen bands on basal margin of one or both intermediate segments. . . . . 2
2. Front before ocelli exceeding one-half eye width in both sexes; male with two pairs of strong proclinate orbitals; wings blackish basally on costal margin. California. (p. 357) . . . . . *nitida*  
    Front before ocelli narrowed to one-fourth eye width and lacking orbital bristles in male; wings subhyaline; female unknown. Texas. (p. 356). . . . . *parilis*
3. Palpi yellow to brownish . . . . . 4  
    Palpi black; parafacial bristles longer than frontals; antennae wholly black; abdomen strongly bristled; male only. California. (p. 355) . . . . . *longiseta*
4. Thorax not distinctly vittate behind suture; proximal antennal segments reddish yellow . . . . . 6  
    Thorax with two broad uninterrupted dark vittae extending behind suture almost to scutellum; proximal antennal segments infuscated; cheek nearly two-fifths eye height . . . . . 5
5. Parafacial gray pollinose, about three-fourths clypeal width; propleura very distinctly haired; male only. Texas. (p. 355) . . . . . *hilaris*  
    Parafacial with satiny light brownish pollen, equal clypeal width; propleura with only two or three short inconspicuous hairs; male only. Wisconsin. (p. 355) . . . . . *hiemalis*
6. Cheek one-fourth eye height; propleura haired; parafacial one-half clypeal width; infrascumal hairs present. Texas, Mexico. (p. 353) . . . . . *chaetosula*  
    Cheek nearly one-half eye-height; propleura bare; parafacial subequal clypeal width, infrascumal hairs absent. Florida (p. 354) . . . . . *hinei*

#### *Muscopteryx chaetosula* Townsend

The principal references to the species have been cited above. Also, most of the essential specific characters have been listed to which may be added the following:

Body rather densely gray pollinose; male front at vertex 0.16 to 0.18 and in female 0.30 of head width; palpi yellow; orbitals lacking in male, the pulvilli elongate and discals on intermediate abdominal segments usually doubled; genitalia blackish; inner forceps united, keeled behind and tapering to a blunt tip which is slightly and subacutely produced on the anterior extremity, outer forceps brownish, rather slender and a trifle shorter; fifth sternite black, with a narrow deep median incision, lobes sparsely black-haired; female genitalia not adapted for piercing.

Four males and one female collected in Bexar, Duval and Hidalgo Counties, Texas, April 9 to May 14 (E. A. Schwarz; H. B. Parks; S. W. Clark). There is apparently no information available concerning the biology or host relationships.

**Muscopteryx hinei**, n. sp.

**Male.**—Front at vertex 0.25 of head width (average of three specimens), narrowed before ocellar triangle thence widening rapidly to antennal base; parafrontals, parafacials and cheeks densely gray pollinose; median stripe reddish, wider than parafrontal except on anterior extremity; parafacial bristles about as strong as average frontal; clypeus only slightly sunk and hardly equal parafacial width; cheek clothed with coarse or bristly hairs, nearly one-half eye height; antennae reaching well below middle of face, first segment slightly elongate, second reddish and about four-fifths length of third; arista black, bare, with short basal segments; palpi moderately slender, yellow; eyes thinly hairy, reaching almost to level of vibrissae; back of head convex and thickly gray pollinose, moderately clothed with pale hairs intermixed with black ones on upper extremity.

Thorax black, densely gray pollinose, notum not distinctly vittate; chaetotaxy as in *chaetosula*; prosternum, propleura, and sides of postnotum beneath calypters bare; infrascutellum normally developed; calypters subopaque, white.

Abdomen slightly elongate, narrower than thorax, black and wholly gray pollinose; first two segments with pair of median marginal bristles, last two with marginal row; one discal pair on intermediate segments and discal row on anal segment; genitalia about as in *chaetosula*.

Legs moderately long, black with an obscure reddish tinge in ground color of tibiae; claws and pulvilli subequal length of apical tarsal segment.

Wings subhyaline; fourth vein with a rounded stumpless bend, thence slightly bowed inward closing first posterior cell at or near costa well before extreme wing tip; hind cross vein bicurved, joining fourth about two-fifths distance from bend to small cross vein; third vein with 5 or 6 setulae extending almost halfway to small cross vein; costal spine distinctly longer than small cross vein; epaulets infuscated.

**Female.**—Front at vertex 0.31 of head width (one specimen), widening gradually from near middle to antennal base; two strong proclinate orbitals present; palpi moderately stout and a trifle thickened apically; claws and pulvilli short; otherwise as in male.

Length, 7–8.5 mm.

**Holotype** male, allotype female, and two paratype males, all labeled "S. Fla., March, 1923," collected by the late James S. Hine, for whom the species is named. The type and one paratype are returned to J. N. Knull, Ohio State University Museum, to whom I am indebted for the privilege of studying this and other material.

The bare propleura may eventually be considered of sufficient importance to preclude the species from the present genus. However, for what it is worth, it may be pointed out that the propleural vestiture in *chaetosula* is subject to considerable variation. One male example in my collection shows only two or three minute hairs on the propleura as compared with a distinctly haired condition in the female type specimen.

***Muscopteryx hilaris*, n. sp.**

Very similar to the preceding species but the thorax distinctly vittate and the propleura haired. Other differences may be noted as follows:

*Male*.—Front at vertex 0.20 of head width; median stripe black, nearly equibroad and wider than parafrontal, latter gray pollinose; antennae blackish, first segment short, second and third subequal in length; parafacial about three-fourths clypeal width, bristles in a slightly oblique row and a trifle shorter than frontals; cheek almost two-fifths eye height, moderately clothed with fine black hairs; palpi slender to tips, yellow; eyes moderately haired, in profile reaching to level of vibrissae. Thorax and scutellum black, with rather thick grayish pollen; notum marked with two broad dark sublateral stripes and a less defined median one which extend behind suture almost to scutellum; chaetotaxy as in *chaetosula*; prosternum bare and sides of postnotum beneath calypters nearly so, latter opaque, white. Abdomen black, wholly densely gray pollinose, moderately elongate and but slightly narrower than thorax; genitalia largely reddish yellow, otherwise about as in *chaetosula*. Legs longish, black except tibiae which are obviously reddish, claws and pulvilli as long as last tarsal segment. Wings normal in shape; first posterior cell closed and short petiolate; third vein with 2 to 4 setulae near base; costal spine slightly exceeding length of small cross vein; epaulets reddish. Length, 7 mm. Female unknown.

*Holotype*: College Station, Texas, March 15, 1937 (H. J. Reinhard). One paratype labeled "Austin, Texas, April 10, 1933," without collector's label.

***Muscopteryx hiemalis*, n. sp.**

Differs from *hilaris* in only minor details and additional material may show it to fall within specific variation of same. To the differences mentioned in the key may be added a few additional items as follows:

*Male*.—Front considerably more constricted upwards and at vertex 0.14 of head width, median stripe also strongly narrowed above middle; parafrontals with light brownish satiny pollen, very narrow at ocellar triangle and widening rapidly downward; sides of postnotum beneath calypters with cluster of fine hairs; genitalia wholly blackish; claws and pulvilli longer than apical tarsal segment; costal spine about equal length of small cross vein; first posterior cell narrowly open; epaulets blackish. Length, 7 mm. Female not known.

*Holotype*: Madison, Wisconsin, June 11, 1925, donated by Dr. C. L. Fluke.

***Muscopteryx longiseta*, n. sp.**

Body blackish in general aspect but not shiny; abdomen conspicuously gray pollinose and strongly bristled. The black palpi readily distinguish the species from all others here included.

*Male*.—Front at vertex 0.15 of head width, hardly widening to middle of front, thence rapidly so downward to antennae; sides

of front and face including cheeks black in ground color, with gray or almost plumbeous pollen; frontal vitta black, strongly narrowed upwards but wider than parafrontal except on anterior extremity; antennae jet-black, third segment a trifle longer than second which bears numerous spiny hairs on front edge; arista short, bare, bulbous near base and very slender beyond; parafacial equibroad, hardly three-fourths clypeal width, bearing a row of seven longish, infra-clinate bristles; proboscis short, stout; palpi black, but slightly thickened apically; cheek with long black hairs, nearly one-third eye height; eyes distinctly but not densely haired, in profile reaching to or slightly below arisal level; back of head somewhat swollen and clothed with short pale fine hairs below middle but with coarser black ones along posterior orbits above.

Thorax and scutellum black dusted with gray pollen; chaetotaxy as in *chaetosula*; prosternum and sides of postnotum beneath calypters bare, latter white and semi-transparent.

Abdomen ovate, slightly narrower than thorax, black, first segment subshining, three following largely gray pollinose; proximal segments each with two pairs of median marginals (outer ones weak), besides several irregularly placed discal pairs on second; third segment bearing a discal and a marginal row, latter long but not uncommonly stout; anal segment wholly bristled above except on narrow basal margin; genitalia retracted, blackish; lobes of fifth sternite subshining, sparsely short-haired.

Legs black, moderately stout; hind tibia with five widely spaced unequal-sized bristles on outer posterior side; claws and pulvilli elongate.

Wings gray hyaline with a slight brownish tinge near base; costal spine about equal length of small cross vein; first posterior cell closed with short petiole reaching costa well before wing tip; third vein setulose nearly halfway to small cross vein; hind cross vein meeting fourth about one-third distance from bend to small cross vein; epaulets black. Female not known.

Length, 7.5 mm.

*Holotype*: Male, labeled, "California, May 19, 1914," no collector's label.

#### ***Muscopteryx parilis*, n. sp.**

*Male*.—Differs from *chaetosula* principally by the characters listed in the accompanying key. Other minor differences may be noted as follows:

Front at vertex 0.14 of head width; antennae entirely black; parafrontals and parafacials subsilvery; eyes moderately densely hairy; thorax and scutellum subshining black, with rather even thin white pollen on notum; propleura distinctly hairy; sides of postnotum beneath calypters bare; legs subshining, wholly black; costal spine subequal small cross vein; epaulets black. Length, 6.5 mm.

*Holotype*: Male, Hartley County, Texas, June 14, 1934.

***Muscopteryx nitida*, n. sp.**

Close to *parilis*, but at once distinguished by the characters listed in the key. Other differences are mentioned below.

**Male.**—Front at vertex 0.24 of head width, equibroad nearly to middle, thence widening moderately downward to base of antennae; frontal vitta velvety black, wider than parafrontal on entire length; parafrontals, parafacials and cheeks with dense gray pollen; frontal bristles moderately strong, decussate; orbitals two proclinate pairs, stout; inner verticals long and slightly divaricate; ocellars smallish but distinct; parafacial slightly narrowed downward with a row of 7 or 8 bristles nearly as long as average frontal; facial depression rather shallow, its lateral ridges bare; epistoma hardly narrower than clypeus and slightly bowed forward from plane of same; vibrissae doubled, main pair stout, decussate, on oral margin well above lower edge of head; antennae wholly black, reaching lower third of face, second segment equal or slightly exceeding length of third; arista black, short, moderately thickened near base; proboscis short, stout, palpi slender to tips, brownish yellow; cheek with sparse coarse hairs at middle, about one-fourth eye height; eyes distinctly but not thickly hairy, back of head evenly convex, gray pollinose, rather sparsely clothed with fine pale hairs below and coarser black ones above.

Thorax and scutellum black, dusted with moderately heavy grayish white pollen; chaetotaxy as in *chaetosula*, but the intermediate post acrostichal is lacking in type specimen; sides of post notum beneath calypters with a few inconspicuous hairs; propleura sparsely to moderately haired; prosternum bare; calypters opaque white, with hind lobes blackish along inner margin.

Abdomen elongate ovate, narrower than thorax, shiny black with silvery pollen on basal margin of intermediate segments; chaetotaxy as in *longiseta*, but the bristles not quite so strong; genitalia black; inner forceps rather broad and short, weakly keeled behind, tapering to near tip, thence divided and slightly divergent with each prong bowed forward on extreme tip; outer forceps a trifle shorter, but much narrower than inner pair in profile view; fifth sternite narrowly and deeply divided, lobes shining black, beset with scattered fine short black hairs.

Legs rather stout, wholly black; hind tibia with a row of five widely spaced uneven bristles on outer posterior side; claws and pulvilli hardly equal length of last tarsal segment.

Wings subhyaline with a brownish tinge along costa becoming darker or blackish towards base; fourth vein with an almost rectangular bend, latter usually without a stump; first posterior cell closed at costa well before wing tip; hind cross vein oblique to fourth which it joins one-third distance from bend to small cross vein; third vein with about five coarse hairs extending almost halfway to small cross vein; costal spine strong; epaulets black.

**Female.**—Front at vertex 0.25 of head width (average of two), widening to 0.40 of same at antennal base; arista yellowish beyond basal enlargement; eyes sparsely haired; abdomen with narrower

pollen bands on segments two and three, sometimes almost wanting on latter; median marginals on first two and discals on intermediate segments in single pairs; genitalia terminating in a blunt-tipped organ, not adapted for piercing; claws and pulvilli short; tarsi somewhat thickened and rather stout.

Length, male, 8 mm.; female, 5.5 to 6.5 mm.

*Holotype*: Male, Pinon Flat, Santa Rosa Mts., California, May 27, 1941, D. J. and J. N. Knull. Paratypes one female, same data as type and one female, Kern County, California, July 19, 1930. The holotype is returned to J. N. Knull for deposit in the Ohio State University Museum Collection.

PARASITIC DISEASES AND AMERICAN PARTICIPATION IN THE WAR, by HORACE W. STUNKARD, LOWELL T. COGGESSHALL, THOMAS T. MACKIE, ROBERT MATHESON, AND NORMAN R. STOLL. *Annals of the New York Academy of Sciences*, Volume XLIV, Art 3. Pages 197-261. Sept. 30, 1943. Published by The New York Academy of Sciences, Central Part West at Seventy-ninth Street. Price \$1.00.

This publication consists of five papers on parasitic diseases as related to America's participation in the war. They were read in March, 1943, at a conference called by the Section of Biology of The New York Academy of Sciences. The titles and authors are as follows: Introduction to the Conference on Parasitic Diseases, by Horace W. Stunkard; Current and Post-War Problems Associated with the Human Protozoan Diseases, by Lowell T. Coggeshall; Changed Viewpoints on Helminth Diseases, by Norman S. Stoll; and Arthropods as Vectors of Human Diseases with Special Reference to the Present War, by Thomas T. Mackie. Each paper carries a short bibliography together with a discussion which followed its presentation. The subject matter is up-to-date and well balanced.

The dispersal of American troops to tropical areas of the world has done much to focus attention upon the importance of parasitic diseases. In their papers, two of the authors, Coggeshall and Stoll, discuss the reservoirs of possible infections in native populations among which our troops are stationed. The importance of arthropods as vectors of parasitic diseases is stressed throughout the publication. The paper by Matheson carries tables of the species of mosquitoes known to transmit malaria, yellow fever and filariasis throughout the world. The recognition accorded parasitic infections by the medical personnel of the armed forces and the part these diseases play in military campaigns is reviewed by Thomas Mackie. He points out that the application of information gained through research, largely since the last war, has prevented our armies from being immobilized by malaria and dysentery.

We are warned that problems of parasitic diseases will not cease with the end of the war. Soldiers with latent and chronic infections will become scattered over the United States after their demobilization. Whether or not some of these tropical parasites may be able to find new intermediate hosts and establish themselves in suitable areas of the United States is a problem about which we need more information.

Several of the authors suggest measures to meet current and post-war problems of parasitic diseases. Thomas T. Mackie suggests "the inclusion of much more parasitology and tropical medicine in the curricula of our medical schools." Horace W. Stunkard adds to this the immediate "organization and establishment of a center for the investigation of parasitic diseases." European countries, with colonial interests, have long recognized the importance of parasitic infections. This is reflected in the strong departments of parasitology, museums, and teaching collections, in their educational institutions. In this respect we have lagged far behind. It appears that the time is near at hand for an expansion of the field of parasitology in the United States.--W. M. TIDD.

# BIONOMICS OF AMAPSOCUS AMABILIS (WALSH)

## (Corrodentia, Psocidae)<sup>1</sup>

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The generic name *Pseudopsocus* Chapman 1930 (1) is preoccupied by *Pseudopsocus* Kolbe 1882 (2); therefore a new name, *Amapsocus*, is here proposed for Chapman's name since it is quite distinct from Kolbe's *Pseudopsocus*.

### *Amapsocus*, new name

*Pseudopsocus* Chapman (1) 1930, p. 287. Genotype, by original designation, also monobasic.—*Psocus amabilis* Walsh. Preoccupied.

*Amapsocus amabilis* (Walsh) is the only species of this genus thus far found in the United States. It is also the only representative of the family Psocidae that has been found on corn during this work. It has previously been recorded from New York, Illinois, Tennessee and Virginia from July to October, with most records about the middle of September. During this work adults and eggs were taken on dried leaves at Mt. Carmel, Connecticut, in October and from dried leaves of oak, maple, buckeye, elm and chestnut-oak during September, October and November in Illinois. Eggs, nymphs and adults were collected on dried corn stalks in a field at Urbana, Ill., June 9 and 19. Eggs were taken from standing corn at Glen Ellyn, Ill., March 14.

Complete descriptions of the adults can be found in the paper by Chapman (1). Reared adults (figs. 1 and 2) were a little smaller than the measurements given by Chapman, probably because they were reared in the laboratory and did not always have an abundance of food.

Of the forty-two species in the family Psocidae reported from the United States, *A. amabilis* is one of twenty-six for which both sexes are known. Males and females were produced in about equal numbers in the laboratory.

*Mating*.—The male apparently sensed the female while still a few millimeters from her. He approached flitting his wings rapidly, then followed along the side of her body until coming to the end of her wings, ran up on top of them and remained poised there for a few moments. He darted down over the front of her head and backed underneath her with his wings held butterfly-fashion. While she

<sup>1</sup>Contribution No. 238 from the Entomological Laboratories of the University of Illinois. This paper was included as a part of a thesis submitted in partial fulfillment of the requirements for the Degree of Master of Science in Entomology in the Graduate School of the University of Illinois, 1941. I wish to express my appreciation of the suggestions made by Professors C. L. Metcalf and W. V. Balduf during this work. Thanks are also due Dr. A. B. Gurney, of the U. S. Bureau of Entomology and Plant Quarantine, for determinations of the species concerned.



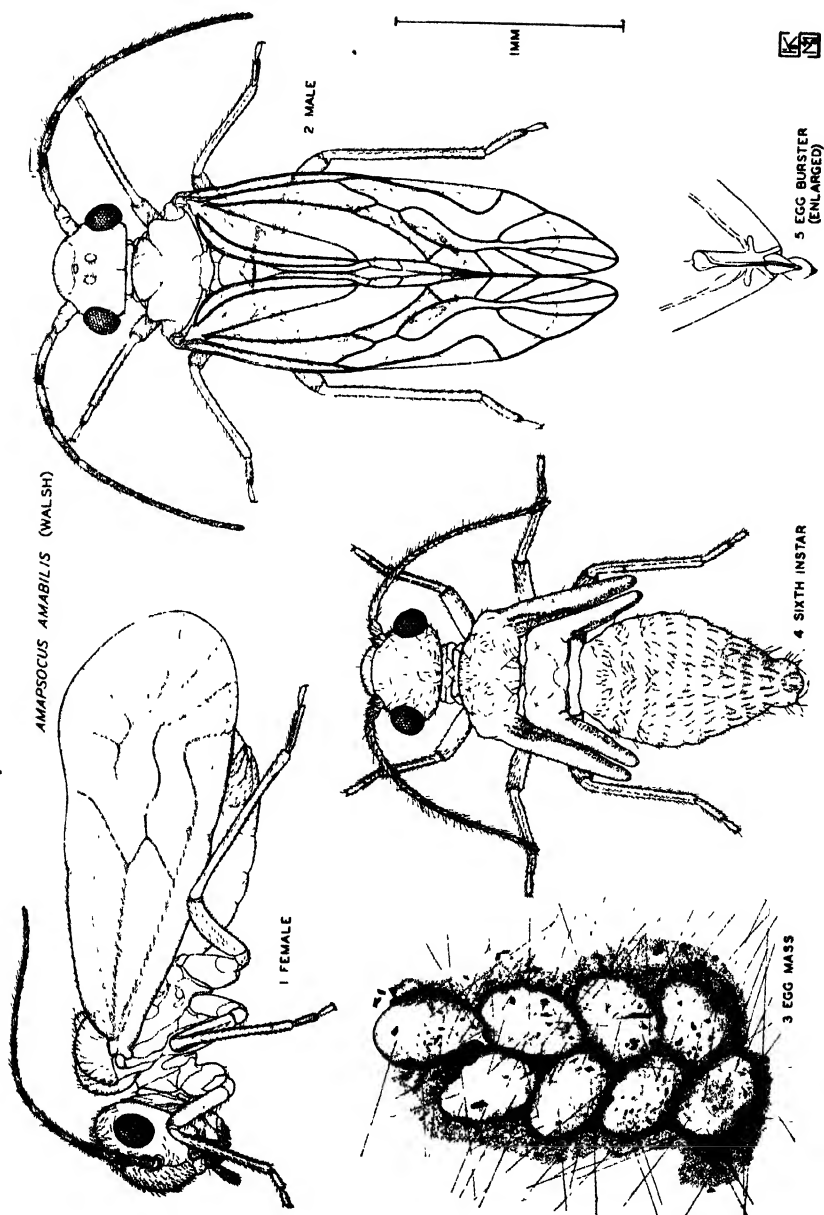
grasped the posterior margins of his wings with her anterior tarsi she was raised to about a 60° angle. The genitalia were fused about fifteen seconds (the female directly above the male), then she turned, detached herself and paid no further attention to his attempts to regain the mating position. For some time the male continued to flit his wings and tried to climb on the female's back. In three instances just after mating the fertilized females were taken out and virgin females put in the rearing tubes, but the males paid no attention to the virgins.

*Oviposition.*—In the field, eggs have been found on the inner surface of the corn leaf sheaths. The eggs were laid in groups of from one to twenty-two, but most commonly in masses of seven or eight and three or four. The last were often found and were probably laid by young females, or by individuals already on the decline.

Egg-laying started from two to four days after moulting to the adult, and continued four to thirteen days. Eggs were not always deposited each day. Young females usually deposited only three or four eggs in the first group whereas the number per group averaged seven or eight during the peak of oviposition, until it dwindled again to one at the end. Small masses sometimes occurred during the middle of the oviposition period. The egg mass (fig. 3) usually consisted of two rows of eggs, the individual eggs being placed herringbone fashion. Adults, collected in the field and put in individual rearing tubes, deposited eggs on the sheath two-thirds of the time, and on the glass the other third. Those reared from eggs in individual tubes reversed the situation, depositing them on the glass two-thirds of the time, and on the sheath the remainder. The smooth glass was something new to the adults collected in the field; so they followed their old custom of laying eggs on the corn. It might be explained that those reared from the eggs in the glass tubes had become accustomed to the smooth glass surface so did not avoid it. Eggs were never deposited on the cotton plugs, as they were in the case of *Lachesilla nubilis* (7).

The number of egg masses per individual ranged from three to twenty-one, with eleven, twelve and thirteen being most common. Sometimes three or four small groups were laid in one day, but usually one mass of seven or eight a day seemed the rule when food was fairly abundant. The maximum number of eggs deposited by any one individual was one hundred and fifteen. Abundance of food apparently affected the maturing eggs because more were laid after fresh pieces of sheath were put in the tubes. Death occurred from one to six days after oviposition ceased.

The actual process of oviposition followed the same sequence as that described for *Caecilius manteri* (5) and *Ectopocus pumilis* (6). The female ran up and down over a small section of the corn sheath. She appeared to be touching the sheath with her labium, much in the same fashion as *L. nubilis* when it attached strands of silk to the corn. Then she touched her abdomen to the corn sheath as if trying to scrape something off by dragging it a short distance. She suddenly stopped and remained perfectly still. A drop of liquid appeared and the abdomen was touched to the sheath. After violent trembling, which lasted about a quarter of a minute, she lifted her abdomen, leaving the egg on



the sheath with the liquid around it. The drop of liquid quickly soaked in. Then for another twelve minutes she nibbled about, up and down on the sheath, until the second egg appeared, and was completely laid in one minute, alongside the first. After nibbling for seventeen minutes the third egg was laid in one-half minute. Twenty-four minutes later the fourth appeared and it was deposited in one and a half minutes. This particular group (fig. 3) finally contained nine eggs; so it is assumed that it required at least two hours to complete the mass, because it took fifty-six minutes to lay the first four.

When the last egg had been laid the female scattered strands of silk across the eggs and attached them to the substratum. Incompleted masses were not at first so darkly covered with granular particles as they appeared to be on the day following the completion of oviposition. For that reason, although it was not observed, there is a possibility that the females deposit on the egg masses a fluid from the anus, similar to *Ectopsocus californicus* (Banks), which has been observed depositing eggs on pieces of corn sheath in the culture tubes. "Daubing" by *E. californicus* has also been reported by McClure (3).

*Egg Stage.*—The eggs are ovate, being slightly larger toward one end. The surface that adheres to the substratum is flat and wrinkled, while the entire curved surface is smooth and shiny. The average length of ten eggs chosen at random was 0.478 mm. and the width 0.324 mm. The eggs are white when first laid, but turn cream-colored as development progresses. The egg mass (fig. 3) shows how a group of eggs (laid on the glass) appears with transmitted as well as reflected light. The masses are densely covered with granular material making it impossible to see the outline of the individual egg by reflected light alone. On the corn sheaths the masses are inconspicuous to the naked eye, appearing like a spot of dirt or fungus sclerotium. Pellets of excrement are often deposited on the egg masses, further concealing them.

There are no evident signs of embryonic development when the eggs are deposited on the sheaths. When the eggs were laid on the glass where the ventral side could be seen, the eyes of the embryo showed through the eggshell the day before hatching. Hatching usually occurred eight days after the eggs had been deposited.

*Hatching.*—Hatching was observed in part once and this particular individual happened to be the last one of the group to emerge. The nymph was already in a perpendicular position, almost completely free from the pronymphal membrane. The egg burster (fig. 5), which lies across the front of the head underneath the pronymphal membrane and attached to it, is wishbone-like in shape with an elongate central shaft having a sharp center ridge terminating in a pointed process with another "knob" projecting beneath it. The central portion and the arms are transparent, the only dark parts being the tips of the two knobs at the extremity of the burster. The pronymphal membrane cast at hatching was found several times entirely free from the eggshell. This suggests that either the pronymph completely freed itself from the eggshell before the membrane split, or perhaps the nymph had difficulty freeing the tip of the abdomen from the membrane; so dragged it a short distance from the egg as it walked away.

*Postembryonic Development.*—The nymphs (fig. 4, sixth instar) are buff, gradually becoming light brown, with no indications of markings, but are very shiny with conspicuous bristly setae on the abdomen. This shiny condition is more pronounced when the alimentary canal is black with food. The antennae are eight-segmented in the first instar and thirteen-segmented thereafter. Wing-pads appear in the third instar and approximately double their length with each successive moult. The duration of the six instar periods was as follows: first, 2.4 days; second, 2.3 days; third, 2 days; fourth, 2.4 days; fifth, 2.8 days, and the sixth, 3.4 days. Similar to *Caecilius manteri* (5), *Ectopsocus pumilis* (6) and *Lachesilla nubilis* (7) the last instar period is longer than any of the others. The averaged measurements in the following table were taken from living specimens, seven to fifteen individuals per instar.

Instar	First	Second	Third	Fourth	Fifth	Sixth	Adult
	mm.	mm.	mm.	mm	mm.	mm	mm
Head width	0.225	0.270	0.349	0.414	0.499	0.584	0.602
Body length	0.726	0.886	1.092	1.192	1.565	1.796	2.172
Forewing length			0.120	0.220	0.407	0.728	1.953

The complete nymphal period required fourteen to eighteen days. The adult stage lasted about fourteen days. The total length of all the life stages was about thirty-seven days.

*Moulting.*—In most cases the nymphs ate the exuviae. The majority of the exuviae that were found were in a vertical position with the head down. Moulting was similar to that observed in the three species previously referred to. The epidermis split along the head and thorax, and the nymph arched up with the antennae held back along the sides of the body. Freeing the head, the nymph gradually rose until it was actually resting on the end of the abdomen. Air bubbles were being swallowed causing the abdomen to lengthen. The antennae and legs were released when it had risen to a vertical position. After exercising the legs and antennae the nymph bent over and stood beside the exuviae. Later the abdomen contracted to its normal length and feeding occurred shortly.

*Habits.*—While under laboratory conditions the nymphs and adults eat fungi, corn sheaths and exuviae. Silk is spun by nymphs and adults but it is not noticeable. This species reacted to moisture the same as *C. manteri*, *L. nubilis* and *E. pumilis*. They sunk their mandibles into the moist cotton plugs and readily drank the water. After a suitable rearing technique was worked out [Sommerman (4)] it was very easy to raise this species because it ate not only the fungus growths but the corn sheaths too.

*Overwintering.*—Eggs found in the field March 14, 1941, were brought into the laboratory where they all hatched. The nymphs were successfully reared to adults for positive determination. Healthy eggs found in the field at that time of the year suggest that the winter is passed in the egg stage in Illinois.

*Summary*.—Adults and eggs of *Amapsocus amabilis* have been taken from Connecticut, New York, Virginia, Tennessee and Illinois. Both sexes are known and the sex ratio is about 0.5. The individual eggs are white when first laid and turn cream-colored as development progresses, but the egg mass as a whole appears dark because the eggs are covered with a granular material and with excrement. The eggs are deposited in groups and are covered with a loose network of silk. Hatching occurs eight days after the eggs have been laid. The antennae are eight-segmented in the first instar and thirteen-segmented thereafter. The wing-pads appear on the third instar and the forewings about double their length with each successive moult. During moulting the nymphs are in a vertical position with their heads down. The nymphal period requires fourteen to eighteen days and the adult stage lasts about fourteen days. The usual life span, including the period within the egg, is about thirty-seven days. The nymphs and adults feed on the various parts of the dried corn plants and the fungi growing there, and they usually consume their exuviae. In the more northern states where this species is found winter is passed in the egg stage.

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## CARBONIFEROUS INSECTS FROM THE VICINITY OF MAZON CREEK, ILLINOIS, by F. M. CARPENTER. Illinois State Museum (Springfield, Illinois), Scientific Papers, vol. III, Part 1: 9-20, 4 pls.

"The ironstone nodules occurring near Mazon Creek, Illinois, are the most important source of Carboniferous insects in North America. Although actually rare in the nodules about 150 specimens have been found during the past 78 years. . . . All nodules in the Langford collection were found at the strip mine of the Northern Illinois Coal Corporation, only a few miles from Morris. The Francis Creek shales, which yield the nodules are part of the Carbondale group (Upper Carboniferous). The Mazon Creek insects are older than those of the famous Commeny shales in Central France."

The Mazon Creek beds are one of the most important collecting spots in the world, for specimens of the earliest types of winged insects. The few fossil insects from this area have been studied and restudied by students of the early history of the Insecta. Handlirsch of Vienna studied them in 1906, and again in 1911 when he gave these few fossils a special publication, "New Paleozoic Insects from the Vicinity of Mazon Creek, Illinois," 80 pages, 63 figures.

Five insects of the Paleodictyoptera and the Protorthoptera are described by Carpenter.—C. H. K.

# OBSERVATIONS ON *COMPERIELLA BIFASCIATA*, AN ENDOPARASITE OF DIASPINE COCCIDS<sup>1</sup>

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The encyrtid *Comperiella bifasciata* How. is of interest primarily as a parasite of the citrus scale insects *Aonidiella citrina* (Coq.) and *A. aurantii* (Mask.). Introduced and established in California by the University of California Citrus Experiment Station in 1924, under the direction of Professor H. S. Smith, in an unsuccessful attempt to control *A. aurantii*, *C. bifasciata* proved to be of considerable value in reducing the frequency of infestations of *A. citrina* on citrus in southern California (Smith, 1942). Because of the economic importance of *C. bifasciata* and the recent discovery that the species consists of at least two host-determined races, it seems advisable to record the biological observations made during the past two years. Compere and Smith (1927) and Ishii (1932) present biological data in relation to hosts other than *A. aurantii*.

The genus *Comperiella* appears to be oriental in origin. Three unquestionably distinct species are known: *C. indica* R. A., reared from *Aspidiotus tamarindi* in India (Ayyar, 1934); *C. unifasciata* Ishii, a uniparental species, reared from *Aspidiotus destructor* in Java and from *Pseudonidia duplex* in Japan (Taylor, 1935); and *C. bifasciata*, a biparental species, recorded from Australia, Java, China, Japan, India, and Mauritius (Flanders, 1934; Gahan, 1927; Silvestri, 1929; Glover, 1935; and Moutia, 1934).

The host genus *Aonidiella* appears to be Ethiopian and oriental in origin (McKenzie, 1938); the host genus *Chrysomphalus* appears to be Australian and Indo-Malayan in origin (McKenzie, 1939).

*Comperiella bifasciata* has been reared from *Aonidiella eremocitri* McK. by the writer. It is a common parasite of *A. taxus* Leon. in Japan and of *A. orientalis* (Newst.) in India. It commonly attacks the yellow scale, *A. citrina*, throughout its range in Japan, China, and India, but is known to attack the red scale, *A. aurantii*, only in China, although both occur together elsewhere. *C. bifasciata* commonly attacks *Chrysomphalus dictyospermi* (Morgan) in Central China and *C. bifasciculatus* Ferris in China, from Shanghai to Peking.

The red scale has wider distribution and exists under more varied conditions than the other hosts of this parasite.

In 1922, a colony of *Comperiella bifasciata* from *Aonidiella taxus* sent to California from Japan was placed on *A. aurantii*, but only 1 male parasite was reared (Smith, 1923). As a result of additional shipments made from Japan in 1925, *C. bifasciata* was established in California on

<sup>1</sup>Paper No. 513, University of California Citrus Experiment Station, Riverside, California.

*Chrysomphalus bifasciculatus* and on *A. citrina*. In 1936, Bess<sup>2</sup> recorded the rearing of 20 males and 10 females of this Japan race from scales that were questionably red scale. In 1932, Compere<sup>3</sup> found, experimentally, that *C. bifasciata* reared from yellow scale on citrus at Poona, India, would not reproduce in red scale grown on citrus at Coonoor, India; it is therefore possible that the Japan race occurs in India.

In 1941, a stock of *Comperiella bifasciata* was obtained in China, from *Aonidiella aurantii* on citrus. This race reproduced abundantly on *A. aurantii* in the insectary at the University of California Citrus Experiment Station; in fact, over two million parasites were reared within fifteen months after introduction. Reproduction of this China race has also occurred to a limited extent in the field in California, but establishment is yet uncertain, and there is no indication that it is able to control red scale.

#### LABORATORY STUDIES OF THE HOST-DETERMINED RACES OF *COMPERIELLA BIFASCIATA*

The Japan and China races of *Comperiella bifasciata* readily interbreed. When reproduced on red scale, the progeny of the reciprocal crosses are equal in sex ratios but markedly unequal in numbers. The reproductive capacity of the females of either race in red scale is unchanged by cross-mating.

Maximum production of the China race (136 offspring per female) occurred when second-instar hosts were exposed to parasitization. There is considerable evidence that such hosts should be feeding on plant fruits having a certain degree of maturity, in order to insure optimum conditions for the development of the larvae of *Comperiella bifasciata*.

After the condition of red scale most satisfactory for maximum production of *Comperiella bifasciata* had been ascertained, females of the Japan race<sup>4</sup> were provided with an abundant supply of such red scale. Surprisingly, an average of 2 offspring per female was obtained.

The fecundity of the China race was found to be about twenty-five times that of the Japan race when the latter was propagated on red scale. (Both races are about equal in fecundity when reproducing on yellow scale.) This difference holds true with unmated females as well as with cross-mated females and is therefore a maternal effect.

As stated by Dobzhansky (1941: 88-89): "... an egg is an organized system which represents the result of a long process of development in the ovary of the mother. The structure, and hence to a certain extent the potentialities, of the egg had been determined before fertilization by the genes in the nucleus of the growing oocyte. ... The characteristics of the development which sets in after fertilization by a sperm of a foreign

<sup>2</sup>Bess, Henry. Unpublished notes on file at the University of California Citrus Experiment Station, Riverside.

<sup>3</sup>Compere, Harold. Unpublished notes on file at the University of California Citrus Experiment Station, Riverside.

<sup>4</sup>In order to be certain that the females of the Japan race were of pure stock, they were obtained from yellow-scale material collected in Tulare County, California, and shipped to the writer by the County Agricultural Commissioner, Oscar L. Hemphill.

species need not be due to the gene complex present in the egg at that particular time; they may have been predetermined much earlier by the maternal genotype. . . [Such a predetermination has been] observed in many intraspecific, as well as interspecific, crosses, and is usually described as a 'maternal effect.'"

The failure to rear the Japan race in red scale, prior to the present work, appears to have resulted from the use of fruit from the field, which was infested with a high proportion of scales unsuitable for the small proportion of eggs inherently able to hatch in red scale. Preliminary tests have shown that the capacity of the Japan race to reproduce in red scale is not increased by breeding from individuals that have developed in red scale.

TABLE I

RESULTS OF FECUNDITY TESTS WITH THE TWO RACES OF *Comperiella bifasciata* HOW., SHOWING A MATERNAL EFFECT THROUGH PROPAGATION ON RED SCALE

Test No.	Parentage	Number of Female Parasites Used <sup>5</sup>	Number of Offspring	
			Average Per Female	Maximum Per Female
1	China Female × China Male.	8	50	136
2	China Female, Unmated	10	41	114
3	China Female × Japan Male	100 ± <sup>b</sup>	47 <sup>6</sup>	
4	F <sub>1</sub> Female (From China Female × Japan Male), Unmated	9	2	7
5	Japan Female × Japan Male . .	12	2	10
6	Japan Female, Unmated	20	2	6
7	Japan Female × China Male .	20	< 1	4

<sup>5</sup>Unless otherwise specified, in these tests one female parasite was used for each red-scale-infested fruit.

<sup>6</sup>The average of three tests, in each of which 100 ± female parasites were used for every 6 to 8 red-scale-infested fruits.

In the present study, the parasites were segregated according to their sex, while in the pupal condition and before they emerged from their hosts. Grapefruit and lemons artificially infested with red scale were used for rearing the offspring. All the scales on a single fruit were the same age. The rearings occurred at temperatures about 80° F. At this temperature the average life of an adult female parasite is about 10 days, a period which equals the duration of the second instar of the red scale.

Results of racial fecundity tests in which each individual female parasite was confined, during its adult life, to a single fruit infested with second-instar red scale, are shown in Table I.

In mass tests, in each of which approximately 100 mated females were confined, during their adult life, to 6 or 8 grapefruit infested with second-instar red scale, results were as follows: When China females were mated with Japan males, in three tests, the offspring per female averaged 51, 43, and 46, respectively. When Japan females were mated



with China males, in three tests, the *total* offspring of all females were 35, 43, and 51, respectively.

#### DEVELOPMENT OF *COMPERIELLA BIFASCIATA* IN RED SCALE

When the red scale and the China race of *Comperiella bifasciata* are reared in the laboratory at a constant temperature of about 80° F., the scale reaches maturity in about 38 days, and the parasite in from 20 to 40 days. The rate of parasite development varies with the developmental condition of the scale at the time of attack. Parasite development is most rapid when the host is in the early third instar and slowest when the host is in the early first instar. The emergence of adult *Comperiella* from scales attacked at any one time may extend over a period of from one to two weeks. Under field conditions in southern California, the minimum life cycle of the parasite, during the summer, is about 30 days in the vicinity of Riverside, 40 days at Anaheim, and 50 days at Chula Vista.

*Comperiella bifasciata*, unlike many encyrtids, deposits the entire egg within the host. The incubation period of the egg, at 80° F., is  $4\frac{1}{2}$  days. The larval period of the parasite consists of five instars. In the minimum life cycle of 21 days (host in early third instar), the first instar of *Comperiella* is 3 days; the second, third, and fourth instars together, 3 days; the fifth instar, 4 days; and the pupal period, 7 days. In the life cycle of 38 days (egg in early first-instar host), it is probable that the first parasite instar extends to 15 days or more.

Embryonic development is unaffected by the host. Larval development, however, during the first instar may be greatly prolonged by the host, the rapidity of parasite development varying with the stage of the host at the time of attack. Development of the parasite during the second instar is affected by the host, but to much less extent. The first instar larva may molt once or twice before the second instar begins.

The development of the host is retarded if it is attacked during the first and early second instars. In such cases the parasite emerges early in the third instar of the host, during the gray stage, rather than later. When scales in the first instar are exposed to attack, the parasites oviposit and their progeny complete their development in both sexes of the host. Male scales, however, are apparently successfully parasitized only when the egg is deposited in the first instar. No parasite eggs have been found in male pupae.

Approximately one-half of the progeny of mated female parasites are female, except when mature hosts are attacked; then females predominate. This may be an effect of the increase in time required for oviposition in mature hosts: the longer the period between ovipositions, the greater the opportunity for the egg to be fertilized and, consequently, become female (Flanders, 1939).

When a mated female is withheld from its host for 2 or 3 days before being allowed to oviposit, it oviposits for several hours at the rate of approximately 3 eggs per hour. The maximum number of progeny obtained from any one mated female was 136, with sexes equal in numbers. These developed from eggs deposited over a 20-day period.

One unmated female produced 114 male progeny. At temperatures of about 80° F., the average life of an adult female parasite is about 10 days, but females not allowed to oviposit may live for 30 days. The average number of adult progeny per female is about 50. There may be considerable superparasitism resulting in a wastage of eggs.

Hosts attacked when in the second instar yield the greatest proportion of parasite progeny. Oviposition by the parasite occurs most readily in hosts of this instar, and there is less mortality of either host or parasite than in the first or third instars.

### BEHAVIOR OF THE ADULT PARASITE

The adult female parasite sometimes feeds on the body fluids of young male and female scales. This is done through wounds made with the ovipositor for the purpose of such feeding. The female may insert its ovipositor through the same wound several times, relocating it by means of the mouthparts and ovipositor sheaths.

When reared on infested grapefruit under insectary conditions, the parasitized scales occur, for the most part, on the ventral half of the fruit, possibly because the female parasites frequent ventral surfaces. (In this connection it is interesting to note that, in the case of the yellow scale on leaves of citrus, the male scales predominate on the upper surfaces, and the female scales on the under surfaces.)

Attraction between the sexes of *Comperiella* is not marked. The number and frequency of contacts between the sexes, before mating occurs, is unusually high. The sexes remain in copulation about 5 seconds. Between periods of oviposition, the females are positively phototropic when the light intensity is increasing and negatively phototropic when the light intensity is diminishing. Females are capable of ovipositing the day they emerge from the host. They are not readily disturbed after oviposition begins. At temperatures below 56° F., the adults are sluggish.

The stimulus for exerting the ovipositor and drilling seems to be produced only by the scale exudation or covering, the ovipositor often being inserted in exuviae of male scale. Much effort is therefore wasted in locating suitable hosts. This habit in such a short-lived species greatly reduces its host-finding capacity, particularly when dead hosts remain on the host plant.

### STRUCTURAL AND PHYSIOLOGICAL CHARACTERISTICS

The egg of *Comperiella bifasciata* is stalked but bears no aeroscopic plate; it is accordingly deposited free in the body cavity of the host. The chorion of an egg that fails to hatch becomes thickened, leathery, and brown in color when deposited in red scale. The reddish accretions which sometimes form in the blood of scales that have been attacked may be mistaken for shrunken, dead eggs.

The most noticeable structural differences in the different larval instars of the parasite are in the form of the mandibles and in the ramifications of the tracheal system. The mandibles of the first instar point anteriorly rather than laterally or posteriorly. Ishii (1932) states that

they point "upward." The mandibles of the second instar are typical, except that the extreme tip of each is bent anteriorly. The mandibles of the other instars are entirely typical. The respiratory system is typical, spiracles appearing only in the fifth instar.

The mid-gut of *Comperiella* is noteworthy in that its contents indicate a urinary as well as a digestive function. This double function is to be expected in chalcid larvae in their early instars, since they lack Malpighian tubules. The contents of the mid-gut of *Comperiella* larvae developing in species of *Aonidiella* include one or more crystalline rods (fig. 1), which may become so long that the mid-gut is ruptured. These rods remain intact in normal salt solution but dissolve instantly in acetic acid. Crystalline structures appear to be absent in the gut of *Comperiella* larvae that develop in *Chrysomphalus bifasciculatus*.

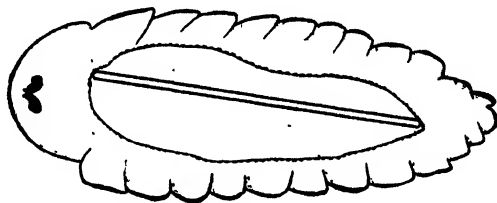


FIG. 1. First-instar larva of *Comperiella bifasciata*, showing position of crystalline rod in mid-gut.

### SUMMARY

*Comperiella bifasciata* How., in its relation to the red scale, *Aonidiella aurantii* (Mask.), consists of two host-determined races. One race is able to reproduce for generations on the red scale; the other race is unable to do so because of its low fecundity when *A. aurantii* is its host. The capacity to develop in *A. aurantii* is shown by cross-breeding to be a maternal effect. The rate of development of *C. bifasciata* during its first instar varies with the developmental condition of the host at the time of attack. The female host is susceptible to successful parasitization in all its instars; the male host, only in the first instar. *C. bifasciata* is most successful when it attacks its host in the second instar. The minimum life cycle of the parasite is 21 days at 80° F. The sexes are approximately equal in numbers. One or more crystalline rods in the mid-gut of the developing larva of *C. bifasciata* indicate a urinary function of the mid-gut.

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**HOW TO COLLECT AND PRESERVE INSECTS**, by H. H. Ross. Natural History Survey Division Circular 39 (Second Printing, with Additions), May, 1944. Pages 1-55, 63 figs.

This helpful manual is apparently used by the Survey to instruct amateur collectors who are willing to collect for the state collections. As the Survey is in the Department of Education it can rate as a supplementary text in biological courses.

It covers: Where to Collect; What to Use; Special Collecting Equipment; Sending Insects for Identification; How to Handle Unmounted Specimens; How to Mount and Preserve Specimens; How to Label; Housing; Identifying the Specimens; Relatives of Insects; the State Insect Collections; How to Ship; Reports on Illinois Insects; Useful Books; Where to Buy Supplies. —C. H. K.

**A REVISION OF THE EMBIOPTERA, OR WEB-SPINNERS, OF THE NEW WORLD**, by EDWARD S. ROSS. Proc. U. S. Nat. Mus. 94: 401-504, pls. 18, 19. 1944.

Seventy-one species are described in seventeen genera and six families. Except for *Oligotoma*, three species introduced, all genera seem to be endemic to the New World. The new species are figured by a total of 156 good line drawings. Species can be determined positively only on the mature male genitalia which have to be treated with KOH and mounted on glass slides. Females and immature forms lack specific characters. Such procedure avoids the use of "weasel words," larger, smaller, denser, etc.

Latin descriptions beginning with Linnaeus in 1758 were well cleared up by 1830. Then followed descriptions in modern languages with the gradual recognition of the impossibility of an exact terminology, a clouded taxonomy now in question. By 1900 the necessity of exact illustrations had become appreciated, and since the work on *Drosophila*, genetic studies have come into the picture. (See p. 365.) In the ants physiological evolution has outdistanced morphological. Name a physiological species! We appreciate figures in this paper by E. S. Ross. —C. H. K.

# THE FEMALE OF AESHNA RUFIPENNIS

(Odonata: Aeshnidae)

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Columbus, Ohio

In these Annals, June, 1941, pages 397-403, I described the male of *Aeshna rufipennis*, n. sp. from Satipo, in the Urubamba Valley of Peru. Shortly after its publication a female and seven more males were received from the collector, Pedro Paprzycki. The female was dated May 23, 1940. One male was undated; six bore the dates May 24, 29, June 3 (2 specimens), 9 and 20, 1940.

The only known female *Aeshna* that this might be confused with is that of *luteipennis* Burm. She is probably the female of *rufipennis* because: 1, *luteipennis* has not been recorded from that area; 2, the female was shipped with seven males of *rufipennis*; 3, all eight specimens were labeled "Satipo" and, 4, all were dated from May 23 (the female) to May 24-June 20 (seven males).

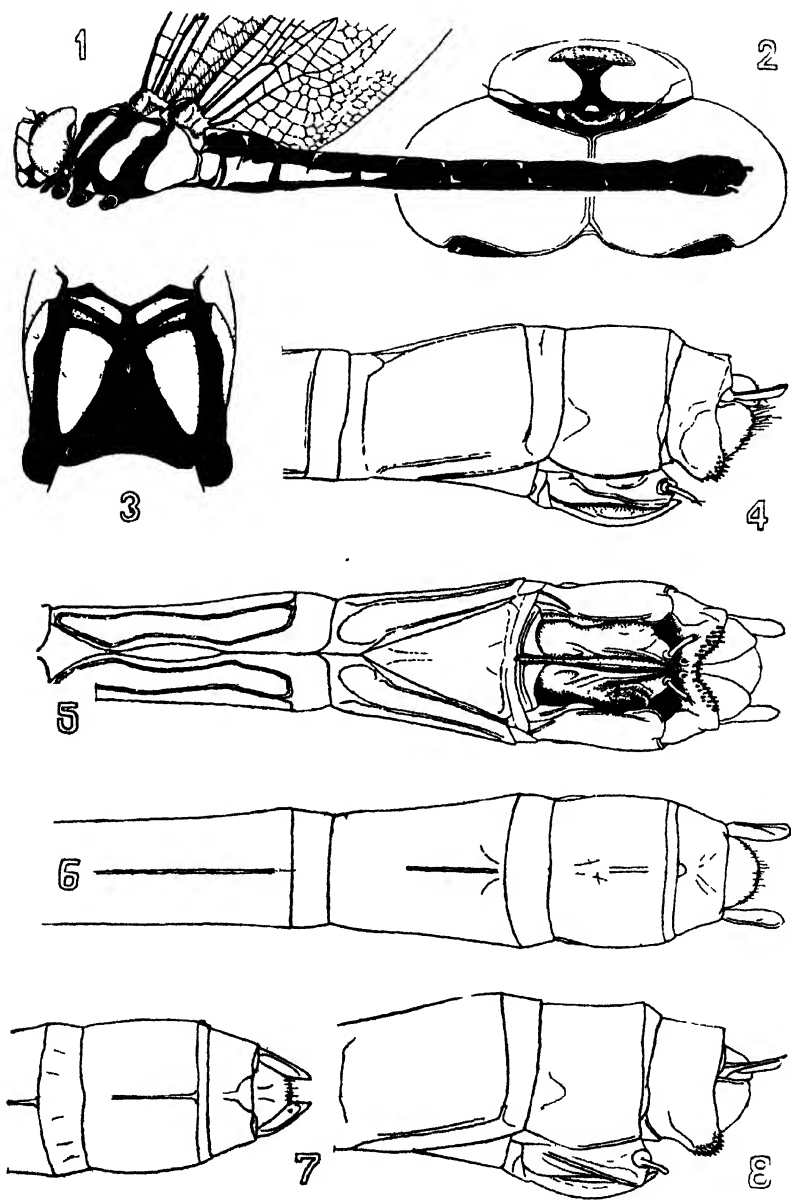
*Rufipennis* has a long season, if it is not on the wing the year around. The four males of the earlier description were dated from Nov. 26 to Dec. 27, 1940. These are from May 24 to June 20, 1940, actually collected by Paprzycki previous to the earlier shipment. Three have clear wings. In none are the wings frayed. In none of the four November and December males were the wings frayed nor were they heavily browned as in aged *Gynacanthas*. The dates of collection, if correct, and the condition of wings suggest a continuous around-the-year flight as in *Anax junius* but seldom found, if at all, in *Aeshna*. Calvert (Biol. Cent. Amer., p. 187, 1905) does not give dates for the close relative, *luteipennis*.

***Aeshna rufipennis*** Kennedy, female, allotype

Figs. 1-6

Length of abdomen 61.5 mm. including appendages which are 1.5 mm.; hind wing 50 mm. long and 14 mm. wide before level of nodus. Stigmas 4.2 mm.

Labium chestnut shading into olive gray on its base; mandibles yellowish shading into chestnut towards the teeth, the pleurostoma black; labrum reddish shading into yellow on the lateral lobes; anteclypeus olive green, postclypeus and vertical surface of frons a medium olivaceous brown with the lateral surfaces of both greenish next the eyes, this green area on either side connected across the horizontal surface of the frons; the T-spot with a broad V-shaped stalk, its narrow base widening around the middle ocellus; vertex, its sulcus and the antennae black, except a minute pale speck entad of each lateral ocellus. The fronto-clypeal suture across the face with a brown hair-line narrowly edged with dull yellow. Rear of

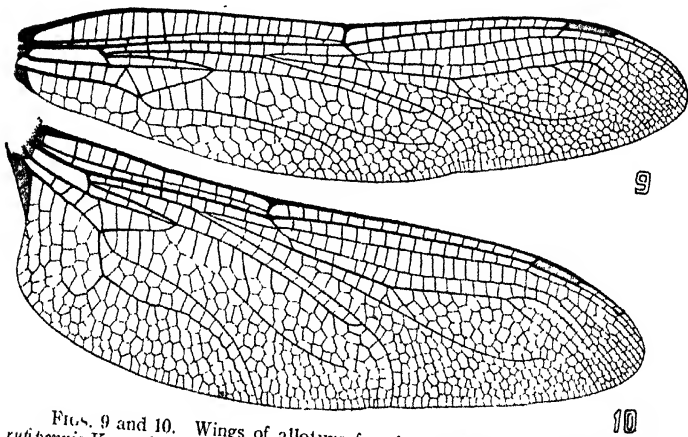


FIGS 1-6. The allotype female of *Aeshna* (*Coryphaeschna*) *rufipennis* Kennedy. FIGS. 7 and 8. The female of *Aeshna* (*Coryphaeschna*) *interpennis florida* Calvert from Juan Vinas, Costa Rica, June 24, 1909, 3400 ft., Calvert collector

head black except a semicircular pale spot crossed by four darker striae on each occipital auricle.

Prothorax black, edged with pale and paler on lower sides. Mesometathorax black with broad dark green markings. The antealar sulcus green, its carinae edged with black; the anterior carina black immersed in a black equilateral triangle; a broad black stripe nearly twice as wide above as below covering the humeral suture and a similar black stripe covering the second lateral suture wider below than above (figs. 1 and 3). The dorsal spots between wing attachments green. The ventral surface of thorax brown with the surface posterior to hind coxae probably greenish in life.

Wings tawny, less so in the median spaces; stigmas brown, veins black; legs black, except coxae, trochanters and bases of femora, all of which are brown.



FIGS. 9 and 10. Wings of allotype female of *Aeshna* (*Coryphaeschna*) *rufipennis* Kennedy.

Abdomen black with a broad tapering lateral green stripe on segs. 1-3 with its point reaching the middle vertical keel on seg. 4. It is interrupted by the apical black rings of segs. 1-3. The lateral stripe is a fusion of the usual spots AL, ML and PL (Walker, E. M., 1912, p. 9). Seg. 1 largely black above; seg. 2 with a narrow middorsal stripe from anterior and extending almost to the vertically narrow MD, the pair of PD forming a middorsal stripe with its widened end across the apex of the segment; 3 with MD a right-angled triangle and PD a minute dot; 4 similar dorsally but with a minute PL; 5 with an L-shaped AL, with MD and PD as in 4 and with no PL; 6, 7 and 8 with a minute dot for AL; and no other dorsal or lateral green; 9 and 10 wholly black. Ventral surface with segs. 1 and 2 brown, segs. 3 to 7 with the brown limited to paired areas; segs. 3 to 7, the entire pleural fold entad to the ventral keel brown; seg. 8 the brown limited to inner edge of anterior end of fold, with an

obscure pale area across posterior fourth of sternum. Base of stylus yellow and an obscure brown spot on side of seg. 9. Seg. 10, cerci, paraprocts and supra anal lobe black.

*Structure*.—Anal appendages (cerci) with parallel sides and obliquely rounded apices (fig. 5). The diagonal lateral ridge on ovipositor sheath sinuous (fig. 4). The spiny area on ventral surface of seg. 10 dumbbell-shaped, viewed from below, its middle one-third as broad as either end. The lower edge of tergite above ovipositor sheath, viewed from the side, evenly rounded.

*Comparison with female of Aeshna (Coryphaeschna) luteipennis florida Calvert*.—In *florida* the anal appendages with an acute apex, the outer sheath of ovipositor with a straight diagonal lateral ridge and the anterior edge of tergite (fig. 8) with a more nearly straight diagonal profile of its anterior two-fifths. Otherwise we have found no differences between the female of *luteipennis* and the female of *rufipennis*. Apparently the color patterns do not distinguish the females of the two species at all easily. Fresh specimens might show color differences.

This female allotype is in the author's collection.

We wish to thank the University of Michigan for loan of material of *Coryphaeschna* and thanks to Prof. P. P. Calvert for loan of other *Coryphaeschna* specimens.<sup>1</sup>

<sup>1</sup>In a letter of August 5, 1944, Prof. P. P. Calvert, after examining the type of *rufipennis* ♀, pointed out that, (1) In *rufipennis* ♀ the second and third femora were reddish at extreme base only (In *luteipennis*, reddish in proximal half.) (2) In *rufipennis* the occiput entirely black (In *luteipennis*, with a dorsal and a posterior yellow spot.) Also that some females of *luteipennis* show a wavy rib on the side of the ovipositor.

ON THE CLASSIFICATION OF THE HISTERID BEETLES, by RUPERT L. WENZEL. Zool. Series, Field Museum of Natural History. Vol. 28(2): 51-151, pls. 1-9, 1944

Besides much discussion of convergent evolution in this family and some rearrangement of genera and subfamilies, the greater part of the volume is given to the description of new genera and new species. Fifty-six new species are described. —C. H. K.

INDEX TO THE LITERATURE OF SIPHONAPTERA OF NORTH AMERICA, by WILLIAM JELLISON and NEWELL E. GOOD, F. S. A., U. S. Public Health Service, Nat. Institute of Health Bull. No. 178; 193 pages, paper bound Supt. of Documents, Washington, D. C. Price \$0.25.

The present very useful publication is a combined product of the Rocky Mountain Laboratory (Hamilton, Mont.) of the Division of Infectious Diseases, National Institute of Health and the Laboratory for Plague Suppressive Measures (San Francisco, Calif.) of the Division of State Relations. It covers the fleas north of Mexico, including Greenland, up to July 1, 1939. "Our publication is intended as a guide to the literature of the species and genera and is not a monographic treatment of the order."

The bibliography occupies pages 164 to 182, the index, pages 183 to 193.

—C. H. K.



# MOSQUITO SURVEY ACTIVITIES AT CAMP PEARY, VIRGINIA<sup>1</sup>

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Early recognition was made of the fact that the mosquito control problem in Camp Peary would be one of magnitude and of immediate importance to the general training program. The Commanding Officer observed that mosquitoes were particularly troublesome during reconnaissance trips in late summer in 1942 in the vicinity of the proposed camp site. Local residents support these observations and readily attest that mosquitoes in past years, in this locality, have been numerous and annoying. The general region has a malaria history and active cases of malaria are still encountered, adjacent to the camp, during the mosquito season. The camp is located along a tidal river in eastern Virginia and in general is heavily wooded. In camp, salt marsh and freshwater breeding areas are extensive. There are three large and two smaller salt marsh areas; the freshwater drainage channels, creeks and small streams are numerous and many of the streams are spring-fed. The terrain varies from rolling hills to flat land; the maximum elevation in the south central region of the camp is about 90 feet above sea level. Generally speaking, the topsoil is a sandy loam underlain in many regions by a layer of sand which is on top of a firm clay subsoil. The area in which mosquito survey and control operations were conducted consisted of approximately 12,000 acres.

In accordance with the recognition that mosquito control would be a problem in Camp Peary and for the purpose of furnishing the mosquito control program with information relative to mosquito breeding necessary for effective control operations, formal mosquito survey activities were started by the entomologist of the Medical Department on April 9 and were continued until November 15. This mosquito survey was an integral and concurrent part of a control program and was not an investigational project; consequently many observations were necessarily omitted as time was a limiting factor. Before starting the survey it was determined that there were no available survey records from previous years for comparative use in formulating plans for the 1943 mosquito control program in Camp Peary. The data in this paper, though limited to one mosquito season, are presented with the hope that it will be helpful to mosquito control workers in comparable regions.

The success of the mosquito survey and control activities in Camp Peary during 1943 was augmented by the support and encouragement given by the Commanding Officer and the Senior Medical Officer.

<sup>1</sup>The expressions contained in this paper are the personal ones of the writer and are not intended to represent official views of the Navy Department.

## I. ORGANIZATION OF THE MOSQUITO SURVEY UNIT

At the beginning of the survey, there were no trained personnel except the officer (entomologist) in charge; the latter carefully trained three chief petty officers and two rated men in mosquito survey and control methods. These men in turn assisted in training ten additional, selected, enlisted men; this detail constituted the nucleus from which the ultimate survey organization (20 men) was formed. The men that were trained for mosquito survey and control activities were selected, when possible, on the basis of their interest in the work and their previous biological and engineering training.

## II. PRELIMINARY WORK OF THE SURVEY UNIT

The first field problem was that of locating all actual and potential mosquito breeding areas. A survey and study of the entire camp was conducted in which all springs, fresh-water streams, lakes, channels, swamps and saltmarshes were located and their limits defined. This survey was completed in two weeks by a detail consisting of three chief petty officers and three rated men. The courses and limits of the various bodies of water and drainage systems were plotted on a map of the camp area.

## III. ORGANIZATION OF THE MOSQUITO SURVEY

The survey was based on two methods: larval inspection and adult mosquito collections. In larval inspection activities the potential breeding sites in camp were inspected for larvae approximately once each week. During one week the freshwater streams, springs, pools, etc., were inspected; the following week a "cross-country" plan was followed in which also all rainwater pools, borrow pits, roadside ditches, etc., were inspected; about once every three weeks the firebarrels, essential artificial containers, etc., were inspected and the saltmarshes were regularly inspected during periods of inundation. The average size of the larval inspection detail was ten men; they worked most efficiently in two men units. Each inspector was equipped with a hollow-handled, white enamel dipper (with a two foot stick inserted), a pipette (large size urethral syringe with tip enlarged), supply of screw-top glass bottles, field notebook, pencil and a supply of strips of white gauze. All breeding sites were marked by tying a strip of gauze to an adjacent twig or weed to assist the maintenance (control) crews in locating the site. Larval specimens were collected from each breeding site, placed in labeled bottles and taken to the laboratory for identification. For convenience the collections were numbered and recorded in consecutive order.

The adult mosquitoes were collected mechanically by means of New Jersey-type light traps and manually in buildings, barrels and from man used as an attractant. Ten mosquito light traps were placed in strategic locations throughout the camp and were operated from dusk to daylight twice each week (Monday and Friday nights). In all cases the traps were located in representative areas adjacent to both fresh and saltwater breeding sites where possible. The traps were suspended by means of a pole and cross-arm device approximately five feet above

the ground and each location was marked by a conspicuous, numbered sign. Power for operating traps was furnished (each trap) by a 6 V. storage battery which operated both the rubber-bladed fan and the 21 candlepower bulb. The batteries (with steel loop attached) were secured to trees by means of a chain and padlock. It was necessary to recharge the batteries after each night of operation. In preparing the cyanide killing jars (quart Mason fruit jar), it was found that it is best to cover the cyanide with a layer of paper towels and then pour a thin layer of plaster of paris over the paper; jars having a thick layer of plaster have an incidence of breakage that is much higher. The insects caught in each trap were emptied into numbered cans (corresponding to trap numbers) and then taken to the laboratory for sorting, identification and counting.

TABLE I  
ADULT MOSQUITOES COLLECTED  
According to Trapping Methods

Type of Trap	Number of Specimens	Per Cent
Light Traps	13,295	83.5
House Traps	1,308	8.2
Barrel Traps	921	5.8
Man Traps	398	2.5
Total Specimens Collected	15,922	100.0

Adult mosquito collections were made by hand in selected locations such as barns, privies, stables, culverts, etc.; fifteen of these sites in camp were visited once each week and all adult mosquitoes present in each location were collected by means of a suction tube and a flashlight. The specimens were killed with ether fumes, placed in a pill-box with appropriate data and then taken to the laboratory for sorting and identifying.

In remote regions of the camp where no buildings existed, adult mosquito resting places were provided by placing wooden barrels (interior blackened) in selected sites. The barrels, with one end removed, were placed on their sides in wooded areas, and brush piled over the top. Each barrel location was marked with a conspicuous, numbered sign. These sites also were visited once each week and the specimens present in each barrel were collected and treated similarly to those collected in the regular mosquito collecting stations.

On the nights that the light traps were operated (twice weekly) adult mosquito collections were made from man, in the vicinity of sentries, at eight locations distributed over camp. The man was placed in the dark and was observed for three minutes at fifteen second intervals for the presence of mosquitoes on his body. A flashlight and suction tube are important items of equipment for this type of collecting. The specimens collected were treated similarly to those collected by other hand collecting methods.

The mosquito survey field notes were compiled each week; the information pertaining to kind, extent and location of breeding along with certain control recommendations was presented to the mosquito control unit in form of a weekly report. A "Jeep" proved to be an ideal means of transportation for all activities concerned with the mosquito survey program.

TABLE II  
AVERAGE NUMBER OF MOSQUITOES TRAPPED PER HOUR IN EACH TYPE OF TRAP

Species	Light Traps	Barrel Traps	House Traps	Man Traps	Total Specimens
<i>Anopheles</i>					
<i>quadrimaculatus</i>	05	1 85	1 47	05	293
<i>punctipennis</i>	76	71	78	14	476
<i>bradleyi</i>	1 79	26	2 34	41	1,092
<i>crucians</i>	15		21		92
<i>Aedes</i>					
<i>solicitans</i>	30	12	13	96	180
<i>taeniorhynchus</i>	4 45	1 31	49	10 45	2,370
<i>vexans</i>	8 50	19	18	1 30	3,891
<i>triseriatus</i>	06			05	26
<i>dupreei</i>	19				86
<i>Culex</i>					
<i>salinarius</i>	11 26	3 76	3 35	4 46	5,765
<i>restuans</i>	55	78	32	09	332
<i>erraticus</i>	13	2 05	1 85		385
<i>apicalis</i>	09	59	37	05	117
<i>Psorophora</i>					
<i>columbiae</i>	39			18	181
<i>ferox</i>	20				89
<i>Theobaldia</i>					
<i>melanura</i>	01	4 20	13		262
<i>Uranotaenia</i>					
<i>sapphirina</i>	57		01		259
Miscellaneous	04	07	04		26
					15,922

#### IV. MOSQUITOES COLLECTED IN CAMP PEARY

Nine genera comprising thirty species of mosquitoes, (twenty-five species of adults and twenty-seven species of larvae), were collected during the 1943 season. The species list is as follows:

*Anopheles*  
  *quadrimaculatus* Say  
  *punctipennis* (Say)  
  *crucians* Wied.  
  *bradleyi* King  
  *barberi* Coq.

*Aedes*  
  *solicitans* (Walk.)  
  *taeniorhynchus* (Wied.)  
  *vexans* (Meig.)  
  *canadensis* (Theob.)  
  *triseriatus* (Say)  
  *dupreei* (Coq.)<sup>1</sup>  
  *atlanticus* D. and K.<sup>2</sup>  
  *cantator* Coq.<sup>2</sup>

*Culex*  
  *salinarius* Coq.  
  *restuans* Theob.  
  *apicalis* Adams  
  *erraticus* D. and K.  
  *peccator* D. and K.<sup>2</sup>  
  *quinqüefasciatus* Say

*Psorophora*  
  *columbiae* (D. and K.)  
  (This name is now  
  widely used for this  
  species.)  
  *cikata* (F.)  
  *ferox* (Humb.)  
  *howardii* (Coq.)<sup>2</sup>

*Theobaldia*  
  *melanura* (Coq.)  
  *ornata* (Will.)

*Mansonia*  
  *perturbans* (Walk.)<sup>2</sup>  
*Orithopodomyia*  
  *signifera* (Coq.)  
  *alba* Baker<sup>2</sup>

*Megarhinus*  
  *septentrionalis* D. & K.<sup>2</sup>  
*Uranotaenia*  
  *sapphirina* (O.-S.)

<sup>1</sup>Only larvae collected.  
<sup>2</sup>Only adults collected.

TABLE III  
SEASONAL RECORD OF ADULT MOSQUITOES COLLECTED BY THE MONTH, ACCORDING TO SEX

Species	April		May		June		July		August		September		October		November		Total Males	Total Females	Total Specimens Collected
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female			
<i>Anopheles</i>																			
<i>quadrimaculatus</i> .....					15	69	24	68	21	54	17	22		6		1	77	216	293
<i>punctipennis</i> .....					21	149	13	128	4	39	4	72		3			45	431	476
<i>crucians</i> .....								18	1	63		9		1			2	90	92
<i>bradleyi</i> .....					18	392	9	359	3	142	3	37		8			35	1,057	1,092
<i>berber</i> .....		16	2					1										1	1
<i>Aedes</i>																			
<i>solicitans</i> .....		10																	
<i>tenoriochus</i> .....			14		1	84	1	157		6		7		4		1	2	178	180
<i>weans</i> .....					27	1,407	7	767	4	193	10	43		4			48	2,322	2,370
<i>canadensis</i> .....		6	4		63	1,620	6	1,664	37	363	17	55	10	4		2	137	3,754	3,891
<i>triseriatus</i> .....								1		2		2						4	4
<i>dayreni</i> .....					1	2			10	31		1					2	24	26
<i>Culex</i>								54										86	86
<i>salinarius</i> .....		3	120		260	2,018	103	1,078	82	225	82	153	17	5	1	1	665	5,100	5,765
<i>restuans</i> .....					12	19	5	16	7	58	22	87	72	14			130	202	332
<i>apicalis</i> .....					11	38	9	48	1	7		1					21	98	117
<i>erraticus</i> .....		1					4	26	48	77	16	69	12	49	6	80	86	299	385
<i>peccator</i> .....								1										1	1
<i>quinquefasciatus</i> .....															1		1		1
<i>Psorophora</i>																			
<i>costalis</i> .....																			
<i>ciliata</i> .....						19	2	106	2	56							4	177	181
<i>ferox</i> .....								1		2							3	3	3
<i>Mansonia</i>						9	19	1	48	13							10	79	89
<i>perfarbata</i> .....																			
<i>Orthopodomyia</i>																			
<i>signifera</i> .....						3				2								5	5
<i>Theobaldia</i>										1								2	2
<i>macdonaldi</i> .....			15			53	4	113									19	243	262
<i>macdonaldi</i> .....		1	3			5												9	9
<i>Uranotaenia</i>																			
<i>sophiae</i> .....					26	123	1	25	9	25	8	38		2			44	215	269
Totals .....	37	164	1,147		459	6,025	183	5,343	211	1,263	244	594	59	99	8	86	1,328	14,504	15,922

A total of 15,922 adult specimens were collected and identified by all trapping methods (see Tables I and II). 83.5% of the total number were collected in light traps, 8.2% in house traps, 5.8% in barrel traps and 2.5% from man. The seasonal trapping record (all methods) of adult mosquitoes by species and by sex is presented in Table III.

TABLE IV  
MOSQUITO LARVAE SURVEY, 1943  
Collection Frequency

Species	April	May	June	July	Aug.	Sept	Oct.	Nov.	Total
<i>Anopheles</i>									
<i>quadrimaculatus</i>			2	7	62	26	6	3	106
<i>penicillatus</i>	8	27	81	94	187	91	45	24	557
<i>bradleyi</i>		3	12	2	5	3	9		34
<i>crucians</i>					2				2
<i>barberi</i>			4	3	1			1	9
<i>Aedes</i>									
<i>taeniorhynchus</i>			6		8	3	9		26
<i>solicitans</i>	7	3			1	5	15		30
<i>canadensis</i> ..	27	5							32
<i>vexans</i>	6	9	15	52	32	26	23	3	166
<i>triseriatus</i>	6	6	14	14	21	4	8	13	86
<i>atlanticus</i>		2		3	1				6
<i>cantator</i>						2	6		8
<i>Culex</i>									
<i>salinarius</i> ..		38	48	51	60	12	2		211
<i>restuans</i>	42	85	84	79	169	100	193	125	877
<i>apicalis</i>	52	36	84	93	230	137	47	34	713
<i>erraticus</i>			1	5	88	33	9	2	138
<i>quinquefasciatus</i>			..		1	24	8	7	40
<i>Psorophora</i>									
<i>columbiae</i>		3	7	83	49	17	1		160
<i>jerrox</i>		1	1	1	5	3			11
<i>ciliata</i>		2	2	4	3				11
<i>howardi</i>			1		7	1			9
<i>Theobaldia</i>									
<i>mornata</i>	10						1		11
<i>melanura</i>				2		2	1		5
<i>Uranotaenia</i>									
<i>sapphirina</i>			1	1	12		..		14
<i>Orthopodomyia</i>									
<i>signifera</i>			7	6	27	8	8	23	79
<i>alba</i>								1	1
<i>Megarhinus</i>									
<i>septentrionalis</i>		1	2	7	7	3	5	6	31

Twenty-seven species of larvae were collected as listed in Table IV, by months, by species; these numbers do not indicate the total number of specimens, but rather the number of times (different locations) in routine larval inspection that they were collected. Two thousand eight hundred and thirty larval collections were made during the season. Observations on larval distribution and larval (species) associations are presented in Tables V and VI; these tables are similar to those used by Owen (8).

For purpose of reference and for use in the malaria control training program, specimens of adults and larvae were preserved. The adult mosquitoes were both pinned and preserved unmounted; permanent slide mounts were prepared of the male hypopygia of various species. Larvae were preserved in alcohol and also by means of permanent slide mounts.

TABLE V  
DISTRIBUTION OF MOSQUITO LARVAE COLLECTED<sup>4</sup> FROM DIFFERENT TYPES OF PLACES

Species	A	B	C	D	E	F	G	H	I
<i>Anopheles</i>									
<i>quadrimaculatus</i>	6	25	9	1	.	.	.	.	237
<i>punctipennis</i>	75	313	89	98	7	2	.	.	90
<i>bradleyi</i>	2	17 <sup>a</sup>	1 <sup>a</sup>	8 <sup>a</sup>	.	.	12	.	.
<i>crucians</i>	1	.	4	.	.	.	.	.	1
<i>barberi</i>	.	.	.	.	.	8	.	.	.
<i>Aedes</i>									
<i>taeniorhynchus</i>	..	3	4	.	.	.	17	3	.
<i>solicitans</i>	..	.	.	.	.	.	19	11	1
<i>rezans</i>	...	65	66	28	.	2	7	.	5
<i>canadensis</i>	1	16	1	14	.	.	2	2	.
<i>triseriatus</i>	....	2	3	.	8	90	.	.	1
<i>atlanticus</i>	..	1	3	1	.	.	1	.	.
<i>canlator</i>	...	.	.	.	.	.	11	.	.
<i>Culex</i>									
<i>salinarius</i>	8	92	19	39	12	3	7	3	23
<i>restuans</i>	49	451	178	222	75	39	.	1	63
<i>apicalis</i>	71	419	102	129	7	4	2	.	55
<i>erraticus</i>	2	7	2	4	2	1	.	.	307
<i>quinqüefasciatus</i>	.	8	10	2	19	.	.	.	.
<i>Psorophora</i>									
<i>columbae</i>	1	11	129	7	.	.	1	.	4
<i>ferox</i>	.	1	8	.	.	.	.	.	.
<i>ciliata</i>	.	2	12	.	.	.	.	.	1
<i>howardii</i>	.	2	5	1	.	.	.	.	1
<i>Theobaldia</i>									
<i>melanura</i>	.	3	.	.	1	1	.	.	.
<i>inornata</i>	.	3	1	1	.	.	4	.	.
<i>Orthopodomyia</i>									
<i>signifera</i>	.	1	1	1	8	66	.	.	2
<i>alba</i>	.	.	.	.	.	1	.	.	.
<i>Megarhinus</i>									
<i>septentrionalis</i>	.	.	.	.	2	36	.	.	.
<i>Uranotaenia</i>									
<i>sapphirina</i>	..	3	.	2	.	.	.	.	37

A—Running freshwater in streams or ditches.

B—Quiet freshwater pools in streams and channels.

C—Small rainwater pools and road ruts.

D—Freshwater seepage pools.

E—Artificial freshwater containers (cans, jars, etc.).

F—Treeholes.

G—Brackish water pot holes and small grassy pools.

H—Brackish water in drainage ditches above high tide or not functioning.

I—Freshwater artificial lake (margin).

<sup>4</sup>Number of times collected.

<sup>a</sup>Region formerly salt marsh area; water now almost fresh.

TABLE VI  
SPECIES ASSOCIATIONS OF MOSQUITO LARVAE<sup>6</sup>

Species	<i>A. n. quadrimaculatus</i>	<i>A. n. punctipennis</i>	<i>A. n. bradleyi</i>	<i>A. n. crucians</i>	<i>A. n. barberi</i>	<i>A. e. sollicitans</i>	<i>A. e. taeniorhynchus</i>	<i>A. e. vexans</i>	<i>A. e. canadensis</i>	<i>A. e. triseriatus</i>	<i>A. e. atlanticus</i>	<i>A. e. cantator</i>	<i>C. salinarius</i>	<i>C. restuans</i>	<i>C. apicalis</i>	<i>C. quinquefasciatus</i>	<i>P. columbianus</i>	<i>P. ciliata</i>	<i>P. ferox</i>	<i>P. howardii</i>	<i>T. melanura</i>	<i>T. normata</i>	<i>O. signifera</i>	<i>O. alba</i>	<i>M. septentrionalis</i>	<i>U. sapphirina</i>
<i>Anopheles</i>																										
<i>quadrimaculatus</i> .....	33	50	1	3				7	1	1			10	14	40	211	6						1		25	
<i>punctipennis</i> .....	50	139	8	1				69	1	3			72	191	342	54	3	15	2	5	2	1	1		10	
<i>bradleyi</i> .....	1	8	8					2	3	1			3	6	6	18	1	1							..	
<i>crucians</i> .....	3	1						5					1			1									..	
<i>barberi</i> .....									7																..	
<i>Aedes</i>																									..	
<i>sollicitans</i> .....																									..	
<i>taeniorhynchus</i> .....																									..	
<i>vexans</i> .....																									..	
<i>canadensis</i> .....																									..	
<i>triseriatus</i> .....																									..	
<i>atlanticus</i> .....																									..	
<i>cantator</i> .....																									..	
<i>Culex</i>																									..	
<i>salinarius</i> .....																									..	
<i>restuans</i> .....																									..	
<i>apicalis</i> .....																									..	
<i>erraticus</i> .....																									..	
<i>quinquefasciatus</i>																									..	
<i>Psorophora</i>																									..	
<i>columbae</i>																									..	
<i>ciliata</i> .....																									..	
<i>ferox</i> .....																									..	
<i>howardii</i>																									..	
<i>Theobaldia</i>																									..	
<i>melanura</i>																									..	
<i>normata</i>																									..	
<i>Orthopodomyia</i>																									..	
<i>signifera</i>																									..	
<i>alba</i>																									..	
<i>Megarsius</i>																									..	
<i>septentrionalis</i>																									..	
<i>Uranotaenia</i>																									..	
<i>sapphirina</i> .....																									..	

<sup>6</sup>Number of times collected together.



## V. CLIMATOLOGICAL CONSIDERATIONS

Climatological data from 1933 to 1943 inclusive for the Williamsburg, Virginia, region were obtained from the U. S. Weather Bureau at Richmond, Virginia. The seasonal weather data for 1943 are presented in Table VII. Weather conditions were observed each night of light trap operation for the purpose of trying to determine the effects of weather on the efficacy of light traps.

TABLE VII  
TEMPERATURE (°F.)

Month	High	Low	Mean	Mean High	Mean Low	Normal (10 years)
April	89	21	55.0	69.9	40.2	56.7
May	91	29	60.2	81.8	56.5	66.1
June	96	61	79.1	90.1	68.1	73.6
July	95	50	77.8	88.1	67.5	77.4
August	96	50	76.6	88.6	64.6	76.2
September	97	38	68.4	81.9	54.9	70.9
October	84	31	57.5	71.3	43.7	60.4
November	78	20	50.9	68.2	33.6	49.7

RAINFALL (inches)

Month	Actual	Normal (10 years)	Wind Direction (Prev.)
April	2.86	3.78	SW
May	5.10	3.89	SW
June	4.35	4.71	SW
July	6.55	6.20	SW
August	1.79	5.83	SW
September	4.03	3.24	N
October	2.78	2.81	SW
November	1.89	2.40	SW

## VI. DISCUSSION

In comparing the results of the various adult mosquito trapping methods, (Table I), it must be borne in mind that the ten light traps were operated for a total of two hundred hours each week; the fifteen house traps were operated for a total of two hours, the fifteen barrel traps for a total of one hour, and the eight man traps for a total of forty-eight minutes. It is apparent, (Table II), that certain species are more readily collected in one type of a trap than in another. For instance, *Anopheles quadrimaculatus* was collected more frequently in barrel and house traps than in light traps; *Aedes taeniorhynchus* was collected more frequently from human beings than by any other method of trapping. The relative prevalence of the various species during the mosquito season is also indicated in Table II. It is believed that climatological conditions directly influence the effectiveness of light

traps. In all instances the largest collections were made on warm, dark, humid nights; the effectiveness was reduced more by moonlight than by rain or wind. 75.4% of the total numbers of adult mosquitoes trapped (all methods) were collected during June and July; the mean low temperatures for these months were 68.1° and 67.5° F. respectively, (Table VII), and the rainfall was close to the normal for the last ten years, (almost eleven inches for both months). It is probable that adult mosquitoes would have been more prevalent during August had not this been a hot and unusually dry month; this year the rainfall was 1.79 inches as compared with the normal of 5.83 inches. The first *Anopheles quadrimaculatus* male was collected on June 12 and the last collection was made on September 25; the corresponding collection dates for female *quadrimaculatus* were June 7 and November 12, respectively. *Culex quinquefasciatus* did not appear until late in the season; an adult male was collected during the first week of November.

Mosquito larvae were more numerous during the months of July, August, September and October, (Table IV). The distribution of larvae collected from different types of places, (Table V) and species association, (Table VI), in general, compares favorably with the observations of other workers. There are, however, some uncommon variations in species associations and interesting occurrences of mosquito larvae. The tree-hole mosquitoes, *Aedes triseriatus* and *Orthopodomyia signifera*, occurred in several locations other than tree-holes, notably in artificial, freshwater lakes. *Orthopodomyia alba* larvae were collected only once during the season, November 13; they were collected together with *Orthopodomyia signifera* from a hole in a stump that extended above the surface of an artificial, freshwater lake. The occurrence of *Megarhinus septentrionalis* larvae in artificial containers and *Culex erraticus* in a tree-hole is of interest. *Anopheles quadrimaculatus* larvae were collected on several occasions in freshwater, artificial lakes, the surface of which was completely covered with *Lemna*. In studying the distribution of the larvae of potential disease-carrying mosquitoes of this locality, it was determined that *Anopheles quadrimaculatus* larvae were collected most frequently along the weedy margins of freshwater, artificial lakes. *A. punctipennis* was found more often in quiet, freshwater pools in streams and drainage channels. *A. crucians* was collected mainly in small, rainwater pools. *Culex quinquefasciatus* larvae occurred commonly in artificial containers and small rainwater pools. Pest mosquito larvae were usually collected in the types of locations with which they are commonly associated. *Aedes sollicitans* and *taeniorhynchus* were generally taken in brackish potholes and grassy, saltmarsh pools. *Culex restuans* and *Aedes vexans* were collected most frequently in quiet, freshwater pools in streams and channels; however, the latter species was taken as often in small, rainwater pools and roadcuts. *Psorophora ciliata* and *columbiae* occurred mainly in rainwater pools and roadcuts. *Culex salinarius* larvae were collected in every type of breeding location encountered, but they were most numerous in quiet, freshwater pools in streams and channels.

Field observations pertaining to the number of times the different species of mosquito larvae were collected together are presented in

Table VI. The habitats in which the larvae were found are divided into nine types, (Table V), each constituting a different kind of community. Certain species occurred concurrently with other species frequently enough to indicate that the particular habitat provided a community mutually suitable for their development and that the species are probably ecologically similar or equivalent, depending on the species. *Anopheles quadrimaculatus* larvae were associated with *Culex erraticus* 211 times, with eleven other species 158 times and they were collected alone 33 times. *A. quadrimaculatus* was taken in 298 different (random) larval collections; 257 of these collections were from artificial, freshwater lake margins and 41 from four other types of habitats (Table V). *Culex erraticus* larvae, as stated previously, were associated with *A. quadrimaculatus* 211 times, with fourteen other species 146 times and they were collected alone 72 times. They were taken in 325 different (random) larval collections; 307 of these collections were from artificial, freshwater lake margins and 18 from six other types of habitats (Table V). *Uranotaenia sapphirina* was associated with *Anopheles quadrimaculatus* and *Culex erraticus* more often than with other species. *Anopheles punctipennis*, *Culex restuans* and *C. apicalis* were collected most frequently in quiet, freshwater pools in streams and channels. Likewise, *Aedes sollicitans*, *taeniorhynchus* and *Anopheles bradleyi* occurred in similar habitats. Other examples of apparent associations of mosquito larvae are presented in Table VI. These associations are not only of ecological interest, but when definitely established, can be of practical value in mosquito control operations. Species control is recognized as being of primary importance in the control of disease-carrying mosquitoes. The presence of larvae that are commonly associated with those of disease-carrying mosquitoes in a certain type of habitat, even though the latter is not present at that time, is an indication either that control measures should be instigated or the location should be kept under close surveillance.

## VII. SUMMARY

For the type of mosquito survey conducted at Camp Peary in 1943, each of the four methods of collecting adult mosquitoes, (light traps, house traps, barrel traps, human beings), was useful and each supplemented the other. When storage batteries must be used to operate light traps, the heavy duty type should be selected. The operation of light traps on bright, moonlight nights did not give an accurate indication of the mosquito population present on those nights. It is essential, for successful operation of barrel traps, that they be located in carefully selected sites and that they simulate a hollow log as nearly as possible. In collecting mosquitoes from man at night, satisfactory results were obtained by having the man strip to the waist. Adult mosquitoes were most prevalent this year during the months of June and July; it is believed that adverse (dry) weather conditions in August caused them to be less numerous than usual during that month. The 1943 records indicate that the active mosquito breeding season in Camp Peary begins in April and continues through October; these dates coincide very well with the average dates (10 years average) of killing

frosts in the Spring, (April 9), and Fall, (October 31), for this region. By planning mosquito control activities accordingly, optimum results can be expected. In general, the distribution of mosquito larvae was similar to that observed by other workers; there were exceptions, particularly among tree-hole breeders in which instances they were collected in sites other than tree-holes. The presence of one or more species of larvae definitely associated with the larvae of disease-carrying mosquitoes, in particular types of breeding locations, can be recognized as an indication of the necessity for mosquito (species) control.

The data included in this paper are not conclusive because they are the results of only one season's activities and additional work in this region would be desirable, especially for purposes of verification of certain of these observations.

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THE ANOPHELINE MOSQUITOES OF THE CARIBBEAN REGION, by W. H. W. Komp. ix+195 pp., 155 figs. National Institute of Health Bulletin 179 Federal Security Agency, U. S. Public Health Service, Washington, D. C. 1942. For sale by the Superintendent of Documents, Washington, D. C. Price 35 cents.

This bulletin is based largely on original comprehensive studies made by Mr. Komp. Thorough descriptions and keys are given for adult females, larvae, and male terminalia of twenty-two species. The illustrations are excellent and the detailed studies of male terminalia, made according to the recent suggestions of Mr. Komp, will elicit particular interest. There are some thirty-five pages of general information, a bibliography, and an index.

An appendix consists of keys, in Spanish, to adult females, larvae, and male terminalia; an interlinear translation into Spanish of descriptions of the female, larva, and male terminalia of *Anopheles albimanus*; a list of entomological terms in English, Spanish, and Portuguese; and a section on susceptibility of the discussed species to malaria infection and ability as vectors of malaria.

—C. E. VENARD.

A KEY TO THE ANOPHELES OF THE SOUTHEASTERN UNITED STATES, BY MALE GENITALIA (Diptera, Culicidae), by LOUIS M. ROTH, in the American Midland Naturalist, Vol. 30, No. 1, pp. 96-110, January, 1944. The University Press, Notre Dame, Indiana.

This key to the 10 species of *Anopheles* found in the Southeast: *barberi*, *albimanus*, *atropos bradleyi*, *crucians*, *georgianus*, *pseudopunctipennis*, *punctipennis*, *quadrimaculatus*, and *walkeri*, is illustrated with 61 figures. Sufficient specimens of the common anophelines were available to enable the author to include data on variation of structures which are of taxonomic value.—C. E. VENARD.

INSECTOS DO BRASIL, by A. DA COSTA LIMA. 1938-1943. Ser. Didática No. 2, da Escola Nacional de Agronomia, Rio de Janeiro, Brazil.

By some turn of fate the ANNALS has just received a second copy of volume three of this extensive work. In the pages of the ANNALS have appeared notices of the four volumes which have covered the insects with incomplete metamorphosis and the Panorpatas, Suctoria, Neuroptera and the Trichoptera. The work is a well illustrated compendium of what is known of the great insect fauna of that vast country. We take this opportunity to summarize the parts which have appeared to date.

Tomo 1. (1938). Pages X and 470. Chaps. 1 and 2, General facts; 3, Thysanura; 4, Collembola; 5, Ephemerida; 6, Odonata; 7, Perlariae; 8, Embiidina; 9, Orthoptera; 10, Grylloblattoidea; 11, Phasmida; 12, Dermaptera; 13, Diploglossata; 14, Blattariae; 15, Mantodea; 16, Isoptera; 17, Zoraptera; 18, Corrodentia; 19, Mallophaga; 20, Anoplura; 21, Thysanura.

Tomo 2. (1940). Pages 1-351. Hemiptera.

Tomo 3. (1942). Pages 1-327. Homoptera.

Tomo 4. (1943). Pages 1-141. Panorpatos; Suctórios Neurópteros; Tri-cópteros.

We wish Costa Lima opportunity to finish this great work.—C. H. K.

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No. 4

DESCRIPTION OF THE MALE OF ERYTHRODIPLAX  
MACULOSA (HAGEN)

(Odonata: Libellulidae)

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**Erythrodiplax maculosa** (Hagen)

*Nannophya maculosa* Hagen, 1861, p. 187. *Ibid.*, 1863, p. 375. *Ibid.*, 1867, p. 90. *Ibid.*, 1874, p. 363. Karsch, 1890, pp. 245, 258. Needham, 1903, p. 722, fig. 17. *Nannothemis maculosa* (Hagen). Brauer, 1868, p. 726. Hagen, 1875, p. 83. De Borre, 1889, p. 26. Kirby, 1889, p. 313. *Ibid.*, 1890, p. 45. Muttkowski, 1910, p. 147. *Erythrodiplax maculosa* (Hagen). Muttkowski, 1910, p. 192. Ris, 1911, pp. 483, 526, fig. 316. *Ibid.*, 1919, p. 1161, fig. 671. Longfield, 1929, p. 130. Needham and Heywood, 1929, p. 214. Borror, 1942, pp. 119-120, figs. 44, 301, 377, Pl. XXXVII.

*Diplacodes friedericella* Forster, 1904, p. 2.

*Diplacodina friedericella* (Förster). Forster, 1904, p. 4.

**Male: Head.**—Labium and labrum black; anteclypeus nearly black; postclypeus yellow; frons metallic bluish black with a yellow spot on each side next to compound eye; vertex metallic bluish black; occiput black; rear of head black, with two small yellow spots on each side of occiput, and two yellow crescent-shaped or wedge-shaped areas on each side behind compound eye.

**Thorax.**—Prothorax with median lobe bluish black, somewhat pruinose; posterior lobe quadrate with distal angles rounded, the distal edge bearing a fringe of long hairs. Synthorax uniformly bluish black and lightly pruinose in adult; in teneral individuals dark brown, darker on dorsum and venter, with numerous irregular light areas. Legs uniformly black, the coxae somewhat lighter and pruinose. About ten spines on outer angle of hind femur, the proximal ones short, gradually increasing in length distally; penultimate spine about half as long as ultimate spine. Tarsal claw (fig. 2) with a small tooth situated at about two-thirds the length of the claw.

**Wings.**—Wings hyaline except for a small basal spot in front wing and a large basal spot in hind wing. Basal spot in front wing largely confined to cubital space, and extending about halfway to cubital crossvein or farther. Basal spot in hind wing brownish black, the

edges yellowish brown, usually with central portion of spot yellowish; this spot extends distally to the third or fourth antenodal, a cell beyond the triangle, and caudad to the outer angle and apex of the anal loop, and to the posterior margin of the wing. Stigma clear ashy yellow; membranule black or dark brown.

**Venation.**—Antenodals in front wing,  $6\frac{1}{2}$  (10%), 7 (10%), or  $7\frac{1}{2}$  (80%); postnodals in front wing, 4 (20%), 5 (10%), or 6 (70%); antenodals in hind wing, 6 (100%); postnodals in hind wing, 5 (90%), or 6 (10%); triangle in front wing free (100%), costal side broken in distal third (100%); triangle in hind wing free (95%) or crossed (5%); subtriangle in front wing 1-celled (40%) or 2-celled (60%); arculus equidistant between first and second antenodals (5%), or nearer second antenodal (95%); base of triangle in hind wing opposite arculus (100%); 1 bridge crossvein (100%); *Mspl* not developed (100%); *Rspl* poorly developed (100%); discoidal field of front wing with 1 (20%) or 2 (80%) cells bordering triangle, followed by 1 (80%) or 2 (20%) cell rows, usually (90%) increasing to 3 rows at about level of nodus; anal loop with 10 (20%), 11 (20%), 12 (30%), 14 (20%), or 16 (10%) cells; intercalary cell in anal loop at anal angle of triangle present (50%) or absent (50%); 3-4 cell rows between anal loop and posterior margin of wing; *Cu*<sub>1</sub> in hind wing arising at anal angle of triangle (100%). Percentages based on 10♂.

**Abdomen.**—General color in adult black or nearly black, with a variable amount of bluish pruinescence, the pruinescence extending at most to segment 6; in teneral specimens there are wedge-shaped lateral spots on segments 3-6, with segments 1-2 largely yellowish. Superior anal appendages whitish yellow with dark tips; inferior anal appendage with anterior two-thirds of dorsal surface yellowish, the remainder of the dorsal side, and the ventral side, brownish black. For structure of anal appendages, and genitalia of segment 2, see figs. 4-9.

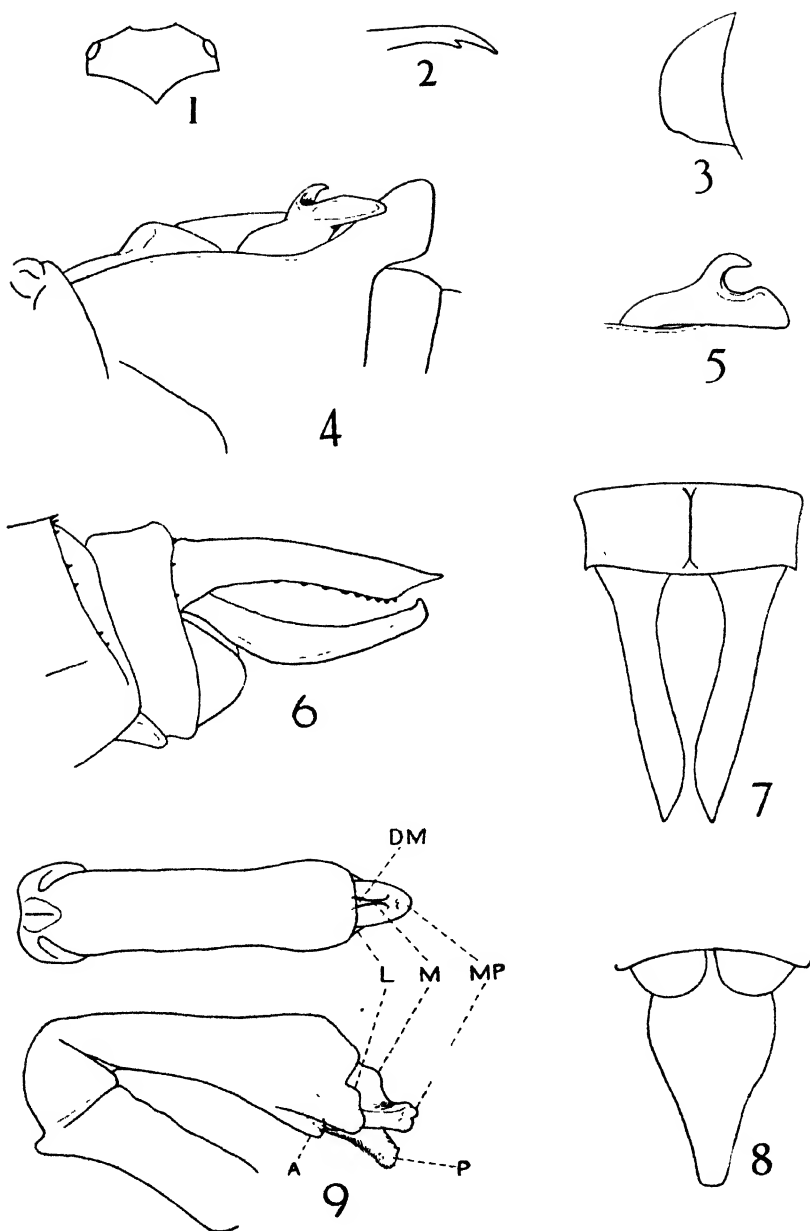
**Measurements.**—Front wing 17 x 5 mm., hind wing 16 x 5.5 mm.; abdomen 15 mm. (specimen from Pirassununga).

**Material Examined.**—9♂, Pirapora, Minas Geraes, Brazil, collected by J. Bailey, May 19, 1941; 1♂, Pirassununga, São Paulo, Brazil, collected by O. Schubart, January 17, 1940. The specimens from Pirapora are in the collection of the writer; the specimen from Pirassununga is No. 2573, Museu Nacional, Rio de Janeiro, Brazil.

#### EXPLANATION OF PLATE

*Erythrodiplax maculosa* (Hagen), male. FIGURE 1. Vertex, dorso-posterior view. 2. Tarsal claw. 3. Frons, lateral view. 4. Genitalia of segment 2, lateral view. 5. Hamule, antero-ventral view. 6. Anal appendages, lateral view. 7. Superior anal appendages, dorsal view. 8. Inferior anal appendage, ventral view. 9. Penis (upper figure, ventral view; lower figure, lateral view); *A*—apical lobe, *DM*—distal meatus of seminal duct, *L*—lateral lobe, *M*—medial lobe, *MP*—median process, *P*—posterior lobe.

Figures 1-8 were drawn with camera lucida; fig. 9 was drawn with projection apparatus from a specimen cleared in caustic potash and preserved in glycerine. Approximate magnifications: of figs. 1 and 3, 10×; of figs. 2 and 4-8, 28×; of fig. 9, 55×.





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THE CADDIS FLIES, OR TRICHOPTERA, OF ILLINOIS, by HERBERT H. Ross. Bulletin of the Illinois Natural History Survey, Vol. 23, Art. 1, 326 pages, 961 figs., 1944.

This addition to the fine entomological monographs of the Illinois Natural History Survey maintains the high standards of previous publications. The two-column page seems a less attractive format than the older bulletins, but its proponents can, no doubt, find advantages in it. The typography is excellent and should contribute materially to the usefulness of the work.

The care expended in offering a thorough and taxonomically accurate survey of the order is noteworthy. Indeed, it seems rather exceptional in a work of limited faunal scope. With the comprehensive treatment of the included species and the many excellent illustrations of larvae, adults and anatomical details it should extend the value of the bulletin far beyond the state of Illinois and should make it a useful manual both to specialists in the group and to entomologists whose major interest lies elsewhere. Dr. Ross is to be congratulated on a truly monumental publication.—A. W. L.

## ADDITIONAL NOTES ON ERYTHRODIPLAX MACULOSA (HAGEN)

(Odonata: Libellulidae)

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At the time of the writer's revision of the genus *Erythrodiplax*<sup>1</sup> only three specimens of this species were known, the type male and a female in European collections, and a female (Förster's type of *Diplacodes friedericella*) in the Museum of Zoology at Ann Arbor, Michigan. Of these, only the latter specimen was available for study. Because of this lack of material, and particularly because no males of *maculosa* were studied, only a brief description could be given in the revision, and the status of the species in the genus could not be stated with certainty.

Through the kindness of Mr. N. Dias dos Santos of Rio de Janeiro, Brazil, the writer has had the privilege of examining a series of eight males and five females of this species, and with his excellent description (see preceding article) it is now possible to determine accurately the status of *maculosa* in the genus.

To Mr. Santos' statement the following might be added:

*Venation* (fig. 3).—A tabulation of the venational characters of the 14 specimens studied gives data very similar to those of Mr. Santos: Antenodals in front wing,  $6\frac{1}{2}$  (7%), 7 (11%),  $7\frac{1}{2}$  (78%), or  $8\frac{1}{2}$  (4%); postnodals in front wing, 4 (7%), 5 (78%), 6 (11%), or 7 (4%); antenodals in hind wing, 5 (7%), or 6 (93%); postnodals in hind wing, 5 (89%), or 6 (11%); triangles in front and hind wings free (100%); costal side of triangle in front wing broken (100%); 1 (19%), or 2 (71%) cells in subtriangle of front wing; in discoidal field of front wing, 1 (11%) or 2 (89%) cells bordering triangle, followed by 1 (96%) or 2 (4%) cell rows for one or two cells, increasing to 2 (4%), 3 (15%), 4 (77%), or 5 (4%) marginal cells; 1 (100%) cubital crossvein in hind wing; 1 (100%) bridge crossvein; Cu<sub>1</sub> in hind wing arising at anal angle of triangle (78%), or slightly separated from it (22%); 2 cells in anal loop of hind wing between bases of A<sub>2</sub> and Cu<sub>2</sub> (100%).

*Penis* (fig. 9, p. 000).—Penis small, terminal segment 0.83 mm. from proximal end to apex of lateral lobes; lateral lobes small, width at base (in lateral view) about one-third as wide as the penis at this point, somewhat quadrate with rounded angles, the dorsal angle somewhat prolonged distally; medial lobes lightly sclerotized, about

Borrer, Donald J. 1942. "A revision of the libelluline genus *Erythrodiplax* (Odonata)." Graduate School Studies, Contributions in Zoology and Entomology, No. 4, Biological Series, pp. xv+286, 41 plates, 1 text figure. Columbus, Ohio: The Ohio State University.

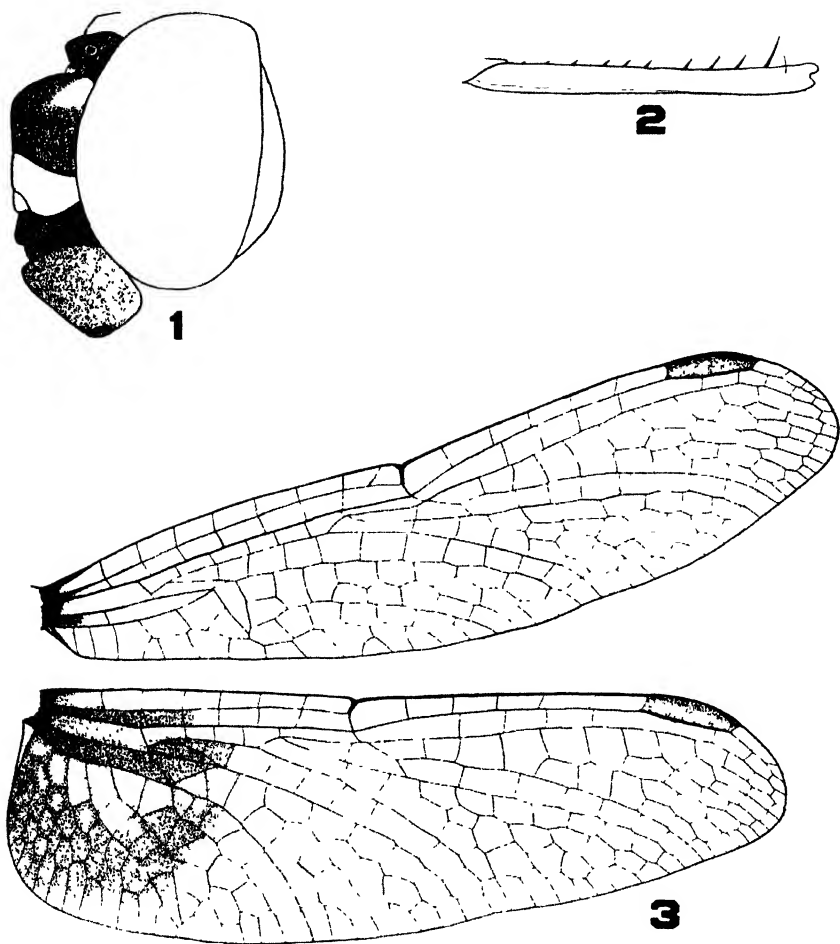
as large as lateral lobes, extending distally beyond apex of lateral lobes and fusing with median process; median process well developed and extending beyond apices of other lobes, somewhat sac-like at apex, its dorsal side with a pair of heavily sclerotized keels which extend proximad as far as apex of apical lobe; no internal lobes; a sac-like, erectile posterior lobe present, arising at the base of median process on dorsal side; apical lobe small, trough-shaped, extending distally as far as base of lateral lobes.

*Measurements*.—♂. Hind wing 16.5–17.5 mm. (average of 8♂, 16.75 mm.), abdomen 13.0–15.0 mm. (average of 7♂, 13.79 mm.), stigma of front wing 1.8–2.1 mm. (average of 8♂, 1.96 mm.) Ris (Cat. Coll. Selys, 1911, p. 527) gives the following measurements for the type ♂: hind wing 15.5 mm., abdomen 12.0 mm., stigma 1.5 mm. ♀. Hind wing 15.5–17.0 mm. (average of 6♀, 16.50 mm.), abdomen 13.0–13.5 mm. (average of 6♀, 13.25 mm.), stigma of front wing 1.8–2.1 mm. (average of 6♀, 1.93 mm.); Ris (*op. cit.*, 1919, p. 1162) gives the following measurements for a ♀ from Matto Grosso: hind wing 17.5 mm., abdomen 14.0 mm., stigma 2.0 mm.

Material examined, 8♂ and 6♀. *Brazil*: Pirapora, Minas Geraes, 8♂ and 5♀, May, 1941 (J. Bailey, in coll. N. Santos). *Paraguay*: Costa Aquaray, 1♀, 1937 (Forster's type of *friedericella*, in coll. Mus. Zool., Ann Arbor, Mich.).

In the writer's revision of *Erythrodiplax* (*op. cit.*), *maculosa* was tentatively placed in the *Basalis* group next to *tenuis* Borror; this position is fully substantiated by the present series of specimens. The penis of *maculosa* is very similar to that of *tenuis*; in *maculosa* the lateral lobes are a little larger and have more rounded angles, and the median process is a little longer. Both species have the postclypeus yellowish and have the yellow lateral spots on the frons; they differ in the size of the basal spot in the hind wing, and in certain venational characters. In *tenuis* the basal spot in the hind wing extends only to the first antenodal, the cubital crossvein or a little beyond, and one or two cells caudad of the membranule (*cf. maculosa*, fig. 3). In *tenuis* the last antenodal is complete (usually incomplete in *maculosa*), and Cu<sub>1</sub> in the hind wing is broadly separated from the anal angle of the triangle (not so in *maculosa*).

In the writer's key to the species of *Erythrodiplax* (*op. cit.*) some specimens of *maculosa* would key out to *basalis* (Kirby) (couplet 29', p. 34). *E. basalis basalis* is usually larger than *maculosa* (hind wing of *basalis* 16.5–25.0 mm., of *maculosa* 16.0–17.5 mm.), the clypeus is black (the postclypeus is yellowish in *maculosa*), and the basal spot in the hind wing does not extend beyond the second antenodal and covers at most only the basal cells of the anal loop, and is bordered by an opal band 1–4 cells wide; in *maculosa* this spot is much larger (fig. 3), it lacks the bordering opal band, and the central portion of the spot is usually lighter in color. *E. b. basalis* occurs in the northern and northwestern part of South America (the Amazonian region of Brazil, Bolivia, Peru, Ecuador, and in Colombia, Venezuela, and the Guianas). *E. b. avittata* which occurs within the range of *maculosa*, has the face entirely bluish black, and is usually larger (hind wing 16.5–22.0 mm., average 20.5 mm.).



*Erythrodiplax maculosa* (Hagen). Figure 1. Head, lateral view. 2. Hind femur of male, showing spination on outer angle. 3. Wings of male. Figs. 1-2 drawn with camera lucida, magnification about  $9\times$ ; fig 3 drawn with projection apparatus, magnification about  $5\frac{1}{2}\times$ .

# FAT INCLUSIONS IN BLOOD CELLS OF THE SOUTHERN ARMYWORM, *PRODENIA ERIDANIA* (CRAM.)

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Many of the blood cells, or hemocytes, of the southern armyworm normally contain glycogen inclusions (4). Whether they also normally contain inclusion of fat has not been reported. An investigation was begun on the existence of fat inclusions in southern armyworm hemocytes and of factors that might influence their occurrence, but it was necessary to discontinue this work before it was completed. The results that were obtained are reported here.

## METHODS

The southern armyworm, *Prodenia eridania* (Cram.), in various stages of development, was used. The larvae were reared on collard leaves and the adults were fed sugar solution. The insects were heat-fixed at 55–60° C. for 5 minutes and blood smears were made in the usual way (4). In a few instances tissue smears were prepared after the blood smears had been made. The insects were dissected in 20 per cent formaldehyde and pieces of tissue were removed to slides, teased apart, and smeared on cover slips. When the blood and tissue smears were sufficiently dry, they were fixed for an additional 15 minutes in 20 per cent formaldehyde. They were then stained with sudan black as follows: 70 per cent alcohol, 30 seconds; alcoholic solution of sudan black B, 30 seconds; 70 per cent alcohol, 30 seconds; distilled water, 3 changes (2). Sudan II, Sudan III, and Sudan IV or Scharlach R were also used but were found less satisfactory than sudan black B. The smears were counterstained in a rose-colored, aqueous solution of pararosaniline hydrochloric acid or with Ehrlich's hematoxylin. Either a cover slip and a dry objective or a water-immersion objective without cover slip was used in examining the smears in water mounts.

A number of smears were stained by the Bauer technique to demonstrate glycogen in the blood cells and polysaccharide, probably glycogen, in the tissues (4).

Larvae were fed fat and carbohydrate in sandwiches. The latter consisted of disks of turnip or collard leaf between which were butter, olive oil, or a mixture of glucose and boiled cornstarch (4).

Blood-fat counts and indices were made in the same way as glycogen counts and indices (4). Four hundred blood cells selected at random were counted and classified as to whether they contained 0, 1, 2, 3, or more than 3 fat inclusions. This constitutes the fat count, having classes 0, 1, 2, 3, and 3<. The fat index consists of the total percentage of the cells that contain fat.

## RESULTS

Fat counts and indices of blood cells were made at different periods in the development of normal *Prodenia eridania* reared in the usual way (3, 4). Only 1 count was made from a single insect. The periods of development and numbers of counts from each period were as follows: First instars, 10; third instars, 10; sixth instars, 10; prepupae, entering ground 2, slightly tapered 1, moderately tapered 8, greatly tapered 8; pupae, early first day 6, late first day 5, second to sixth days 10 each day, eighth day 2; adults, first day 4, second day 4, fourth day 2, fifth day 1. The manner in which the fat indices corresponding to these counts varied during the life of the insect is shown by the solid dots in figure 1. Only part of the sixth stadium is represented,

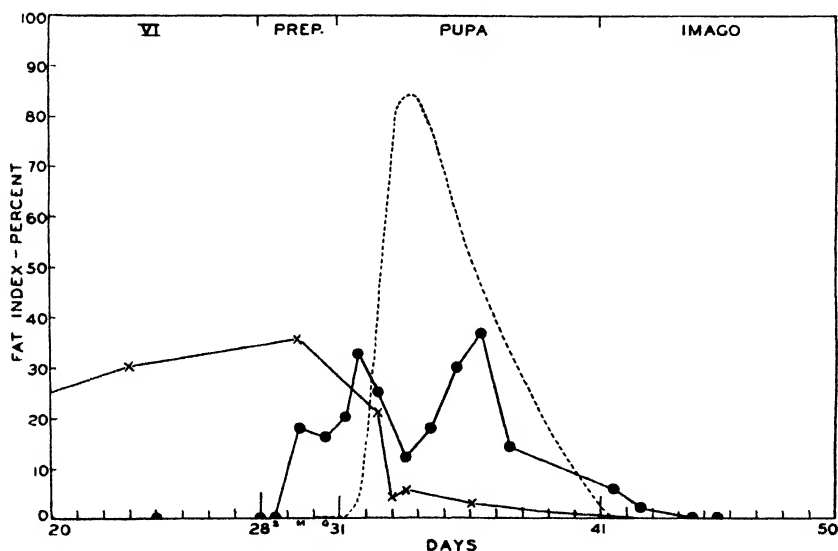


FIG 1

FIGURE 1. Variation in percentage of hemocytes that contain fat inclusions during development of the southern armyworm, *Prodenia eridania* (Cram.). Fat index shown by solid dots, glycogen index (for comparison) by crosses, and plasma fat (nonquantitative estimate) by broken lines. Sixth stadium indicated by VI and days after hatching by arabic numerals. S, M, and G indicate slightly, moderately, and greatly tapered prepupae. Prep. means prepupa.

because no blood-cell fat was observed during the larval life of the normal insects reared on collard leaves. The broken-line curve is not based on quantitative counts. It represents only an opinion of how the fat in the plasma, exclusive of blood-cell fat, rises to a maximum and falls again to zero. This opinion is based on rough estimations of plasma fat in the smears from which the hemocyte-fat counts were made. The crosses represent the rise and fall of glycogen as indicated by the glycogen indices reported previously (4). Whereas blood-cell glycogen appeared shortly after hatching and rose gradually to a

maximum at about the middle of the prepupal stage, blood-cell fat did not appear until near the middle of the prepupal stage. The fat rose as the glycogen decreased. From the middle of the prepupal to beyond the middle of the pupal stage the index of blood-cell fat fluctuated about the 20-25 per cent level, then decreased. It disappeared in early imaginal life. Plasma fat appeared suddenly and rose very rapidly to a maximum at about the second or third day of pupal life. After that it fell quickly and disappeared at about the time of emergence of the adult.

The fat counts tended to have the same form as that already reported for glycogen counts (4) and, like the latter, are expressions of frequency distributions. This form is represented by  $0 > 1 > 2 > 3 < 3+$ , where the numbers represent the classes and the symbols their numerical relationship. About 12 per cent of the fat counts had the form  $0 > 1 > 2 > 3 > 3+$ , exceeding the percentage of the glycogen counts showing this form. Figure 2 shows how the fat count varies as

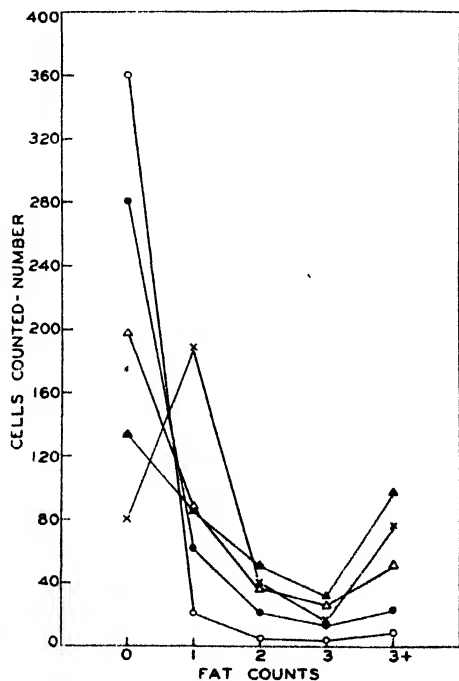


FIG 2

FIGURE 2. Variation in hemocyte-fat counts with change in fat index. Ordinate shows number of cells counted; abscissa, the classes of the count, based on whether a hemocyte contains 0, 1, 2, 3, or more than 3 fat inclusions. An average of those counts whose fat indices vary from 0-20 per cent (mean of 10.0 per cent) are shown by open circles, from 20-40 per cent (mean of 28.8 per cent) by solid dots, from 40-60 per cent (mean of 50.4 per cent) by open triangles. Single counts are shown by solid triangles (index of 66.5 per cent) and crosses (index of 80.0 per cent).

the fat index rises. This relationship is the same as that between glycogen counts and indices. The fat counts having indices of 66.50 and 80.00 are single counts, the others averages; this probably explains the crossing of the curves.

A few sixth instars were fed turnip-leaf sandwiches that contained butter or olive oil. Fat inclusions began to appear in the hemocytes in about 45 minutes. Considerable fat was observed at 1.5 and 3.0 hours after feeding. Too few experiments were done to indicate any differences in the use of butter or olive oil. Ingestion of each was followed by the appearance of blood-cell fat. One or two droplets of fat appeared occasionally in the plasma.

When fifth instars were fed for about 24 hours on sandwiches containing glucose and cornstarch, the ingestion of the excess carbohydrate did not cause fat to appear in the hemocytes, although duplicate smears stained by the Bauer method indicated that glycogen had increased considerably.

In tissue smears from normal sixth instars, material stained with sudan black B, considered to be fat, was found in the following tissues: Fat body, Malpighian tube, nerve cord and ganglia, salivary gland, gonad, body muscles, and midgut epithelium. It was found less definitely in the pericardial cells. Its presence in heart-muscle and alary-muscle fibers was questionable. It was not found in trachea or peritracheal tissue. In the normal larvae reared on collard leaves the fat in the epithelial cells of the gut consisted of fine granules. After ingestion of sandwiches containing butter or olive oil, the gut cells became loaded with large fat inclusions, which were stained with the sudan black.

## DISCUSSION

Cellular details could not be distinguished as well in the smears fixed in formaldehyde, stained with sudan black and mounted in water, as in smears stained for glycogen and mounted in balsam or clarite. The fat counts and indices consequently involved a greater error of counting than did the glycogen counts and indices previously reported (4). This might account in part for more fat than glycogen counts having the form.  $0 > 1 > 2 > 3 > 3+$ . Whether, as in the glycogen counts, this form reflects the lack of fat inclusions in certain kinds of blood cells was not determined.

Although blood-cell glycogen rose gradually during larval development, cellular fat detectable by this histochemical method normally did not appear until the prepupal stage. During the prepupal stage the total glycogen content of the insect (1), as well as its blood-cell glycogen, rose to a maximum at about the time of pupation. In the latter half of the prepupal stage, when total glycogen and probably blood-cell glycogen were on the increase, blood-cell fat rose also. It is apparent that metamorphosis ultimately involves a decline of blood-cell glycogen and a rise of blood-cell fat, but a connection between the two changes is not shown by these data. It does not follow necessarily that the blood-cell fat was formed by a transformation of glycogen, although such might actually have occurred. The failure to produce blood-cell fat by feeding the larvae excess carbohydrate in the few experiments



carried out would seem to argue against the origin of blood-cell fat from blood sugar and presumably from glycogen by way of blood sugar. The production of fat in hemocytes by feeding fats to the larvae suggests a lipid origin of the fat that appeared in the hemocytes during metamorphosis, possibly from the lipoids of the fat body. It is possible that some of the fat droplets liberated by the adipose tissue during metamorphosis might have been phagocytized by hemocytes (3) but most of the fat inclusions in the blood cells are not considered to have originated in this way.

The feeding of excess fat to sixth instars has shown that the blood cells of these larvae have the capacity to contain fat inclusions but ordinarily are not called upon to use it.

The plasma fat appeared as droplets floating free in the plasma and as inclusions in the tissue debris that appears in the circulating blood during metamorphosis. The tissue debris is considered to consist almost entirely of liberated fat body cells, and the free fat droplets probably originated from the adipose cells (3).

### CONCLUSIONS

The hemocytes of southern armyworm larvae, reared on only collard leaves, contain practically no fat inclusions before the insect reaches the prepupal stage. Fat inclusions first appear in the prepupal stage, are found throughout the pupal stage, and practically disappear in the first part of the imaginal stage. In general, fat appears and continues to be found in the hemocytes as glycogen disappears from them. Droplets of fat, as well as liberated adipose cells, are present in the plasma during metamorphosis.

The hemocytes of sixth or earlier instars can contain fat inclusions if the larvae ingest sufficient fat (butter, olive oil) in their diet.

Like glycogen counts, hemocyte fat counts represent frequency distributions. They tend to have the form  $0 > 1 > 2 > 3 < 3+$  and to exhibit a maximum in a higher class as the fat index increases.

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# NUTRITIONAL REQUIREMENTS OF CAMPONOTUS ANTS<sup>1</sup>

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It has been shown that the amount of food received by colonies of *Camponotus* influences imaginal stature among the workers produced (Smith, F. 1942). The following experiments were performed to see if the quality of the food received by *Camponotus* colonies would influence the size of the workers produced. *Camponotus herculeanus* subspecies *pennsylvanicus* DeGeer is probably both aphidicolous and entomophagous because the workers are commonly observed visiting aphids on the branches and leaves of trees. They will also readily attack and devour insect larvae that are given to them, whether in the laboratory or in the runways of their nests out-of-doors.

It was first necessary to find a complete basal ration whose constituents might be altered in a known way. For this purpose recent literature on insect nutrition was searched in order to find records of synthetic diets which could be used in the experiments.

The basal diet prepared for the experiments with *C. pennsylvanicus* contained the following materials in the proportions shown: casein, 1.8 gms.; sucrose, 6.6 gms.; fat, 0.2 gm.; linoleic acid, 0.05 gm.; cholesterolin, 0.05 gm.; salt mixture,<sup>3</sup> 0.3 gm. This basal diet was then supplemented with 0.9 gm. of Brewers' yeast. In preparing the food it was found best to pulverize the granulated sugar in a mortar and then add the other materials, being careful thoroughly to mix all the ingredients. The food was stored in a refrigerator until it was used.

*Camponotus pennsylvanicus* colonies were brought to the laboratory where they were placed in Fiedle nests arranged as will be described later. All experiments were carried on in a warm room (25°-30° C.) and each nest received as nearly identical treatment as possible. There was constantly present in the nests an abundance of both food and distilled water. Each nest was examined every second day from the start of the experiment until its termination. At every inspection pupae, if present, were removed, and worker eggs were destroyed when they were found. Care had to be taken to remove every trace of old food or other refuse from the nest so that the fresh food would not become contaminated. Pupae were weighed immediately on removing them from the nest and their weight as well as the date of their appearance was recorded.

<sup>1</sup>This study is condensed from a portion of the dissertation presented to the Faculty of Harvard University in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

<sup>2</sup>Contribution No. 11, Department of Zoology and Entomology, University of Tennessee, Knoxville.

<sup>3</sup>U. S. Pharmacopoeia, 1939 (Supplement), p. 132.

The method used in feeding the ants was simple. A drop of distilled water was placed in the center of a one-inch square of heavily waxed paper. To this drop of water was added a small amount of the food. The water and food were then mixed with a glass rod to form a thin paste. This square of paper containing the food was then placed in the nest. At the next inspection of the nest the square of waxed paper was removed and a fresh one, containing food, was added. A small cotton swab moistened with 95% alcohol was used to clean the floor of the nest.

#### THE INFLUENCE OF VARYING AMOUNTS OF DIETARY PROTEIN UPON CAMPONOTUS PROGENY

The following experiment sought to discover whether the stature of *Camponotus* progeny might be altered by changes in the amount of protein in the food received by the colony. Since it is impossible to control the amount of food the ants eat, except within very wide limits, it turned out that a decrease in one of the main components in the basal ration fed to the ants resulted in an increase in all the other components. Thus, if the amount of casein were halved in the preparation of the food, there would be a proportional increase in the other materials. This meant that instead of dealing with the one variable, i. e., the amount of casein, the experimenter was confronted with a number of variables represented by the amount of each substance in the synthetic diet. Nevertheless it was felt that adequate amounts of each constituent were present in the diet even where the dilution was greatest.

Two large colonies of *C. pennsylvanicus* were collected with their larvae. Into each of fifteen Fiedle nests there were placed 30 nurse ants selected at random from the parent colonies, together with 95 larvae. The distribution of the ants and their larvae is made clear from an examination of Table I. The feeding of all nests was begun at the same time and was continued for 68 days.

Five lots of basal diets lacking in casein were now prepared and placed in vials numbered 1 to 5. To these vials there was added technical casein in such a way that the first contained the least amount of casein and the fifth vial contained the greatest amount. The amounts of casein used were as follows: 0.2 gm., 0.9 gm., 1.8 gm., 3.6 gm., 5.4 gm. These diets were then fed to the ants and the results are shown in Table I.

Individual larvae were not weighed to obtain the average weight per larva at the start of the experiment. The 95 larvae were weighed en masse and the average weight per larva was calculated. While this method is only approximate in its results it does provide a basis for the comparison of larval size among the experimental nests.

The number of pupae produced is seen from Table I to vary considerably, and this variation is correlated with the quantity of dietary casein in only one instance. Where 5.4 grams of casein was used in the diet, the numbers of pupae produced were markedly less than was found true in those nests receiving a smaller amount of casein in their food. This reduction in numbers of pupae is interpreted to be due to an inadequacy in the diet which contained 5.4 grams of casein, and indi-

cates that a rich protein diet is not a satisfactory one for *C. pennsylvanicus* colonies.

From the relative weights of the pupae produced in the nests it is clear from Table I, that a protein-rich diet is an unsatisfactory one for *Camponotus* colonies. With a diet containing 5.4 grams of casein the average pupal weights were always less than when a smaller amount of casein was used. Unfortunately a graded series of pupal weights corresponding to the amounts of casein in the food, was not obtained in this experiment. This is thought to be due to factors other than dietary ones, which were not under control during the course of the experiment.

TABLE I  
DATA TO SHOW THE INFLUENCE OF VARYING AMOUNTS OF DIETARY  
PROTEIN UPON *Camponotus* PROGENY

Nest	Casein Content of Diet in gm	Average Weight Per Larva at Start in mgm	Number of Pupae Produced	Average Weight per Pupa in mgm	Average Head Width of Progeny in Ocular Units	Standard Deviation of Head Width
K	1	0.2 gm	59	8.03 mgm	42.7	8.27
	2	"	52	7.53	44.2	7.88
L	3	"	17	16.62	40.7	
K	4	0.9 gm	46	6.91	44.4	7.40
	5	"	48	7.66	41.2	8.48
L	6	"	21	16.70	46.7	8.56
K	7	1.8 gm	59	7.94	44.0	5.50
	8	"	48	8.53	44.1	9.40
L	9	"	21	16.74	49.0	8.34
K	10	3.6 gm	55	8.49	45.1	8.98
	11	"	58	7.53	43.3	7.78
L	12	"	15	19.2	44.0	
K	13	5.4 gm	20	6.6	39.5	3.50
	14	"	17	7.0	44.6	10.7
L	15	"	10	11.5	46.2	6.11

Comparison of the average pupal weights with the average larval weights shown in Table I, indicates that the pupal weight is correlated with the weight of the larva at the beginning of the experiment. This correlation was not constant, however, as can be seen by comparing the weights of the larvae and pupae produced in nests 1, 2, 4 and 5. There is a correlation seen elsewhere in Table I, between the larval weights which suggests that determination of imaginal size in *Camponotus* must occur at an early stage in the life history of these ants, but that, despite this fact, adult stature can be altered by conditions which exist between the time that imaginal size is determined and the time of pupation. Other than this nothing is known about the time of size determination among incompletely polymorphic ants such as *Camponotus*.

Average head widths of the ants produced in the experiment are seen from Table I to vary considerably. There is shown however, a tendency toward the production of individuals of smaller stature where a protein-rich diet was fed to the nurse ants.

Calculations upon the range of variation in stature of the ants produced in these nests were made, and the standard deviation in Table I expresses this range of variation for the imagines produced in each nest. The standard deviation was shown to be a useful index of nutritional conditions in colonies which were under-fed, Smith op. cit. The standard deviation of the workers produced in nests 3 and 12 could not be calculated because the progeny consisted largely of males in these two nests. It is evident from Table I that in two nests at least (13 and 15), a protein-rich diet resulted in a marked reduction of the variation among the imagines produced. In this respect the ants produced in nest 14 were at considerable variance from those produced in the other nests.

A diet, rich in proteins, has a deleterious effect upon the progeny in colonies of *Camponotus pennsylvanicus*. This harmful effect is noted in several ways: fewer of the larvae attain to pupation in the colony; the average pupal weights are less; and the standard deviation of the head widths and hence the stature of the imagines produced, is less when a protein-rich diet is supplied to the nurse ants.

#### THE EFFECT OF A SALT-FREE FOOD UPON THE PROGENY OF CAMPONOTUS COLONIES

The following experiment was undertaken to discover whether the salt mixture employed was of value as a nutritional component in the synthetic diet fed to colonies of *C. pennsylvanicus*. The basal diet already described was fed to the ants in the control nests, and a new diet was prepared in the same way as the basal diet except that no salt mixture was added to it.

Colonies K and L, used in the previous experiment, again supplied larvae and nurse ants for use in this experiment. 30 ants, selected at random from the parent colonies, were placed in each Fieldc nest. The ants were given 95 larvæ, weighed as before. Pupae were removed and weighed immediately upon removal from the nest. The experiment was carried on for 68 days, and all conditions were kept as nearly uniform as possible for each nest.

Table II summarizes the results obtained in this experiment and it is seen that nests 1, 2 and 3 are the controls for nests 4, 5 and 6, respectively.

The larval weights at the start of the experiment are shown in Table II. There is seen to be a large variation in the average weights of the larvae used.

A nearly equal number of pupae was produced in the nests, and it is clear from Table II that the removal of the salt from the diet had no appreciable influence upon the numbers of pupae produced in the nests.

Removal of the salt mixture from the diet fed to the ants in nests 4 and 5, resulted in pupae whose average weight was greater than the average weight of pupae produced in the control nests 1 and 2. The apparently anomalous pupal weights in nests 3 and 6 may be explained by the fact that a large percentage of the pupae produced were males.

Comparison of the average head widths of the imagines produced in the experiment under consideration, reveals that individuals of larger stature result in every instance where the salt mixture was removed from the diet fed to the nurse ants.

Finally, from Table II, it may be seen that the standard deviation of the head widths of the progeny in nests 4, 5 and 6 was greater than was found to be true in the control nests. Thus, the salt mixture employed in the basal ration evidently inhibited variation among the progeny.

The findings noted above lead to the conclusion that the salt mixture inhibited in some way the normal growth of the developing larvae. It is difficult to explain this negative reaction to a salt mixture which is known to be an adequate one for vertebrate animals (see McCollum, E. V. 1939, chapters 7-10). Unfortunately, little is known of insect requirements for mineral nutrients (Trager, Wm., 1941) and from the results obtained in this experiment it is seen that some ion or group of

TABLE II

DATA TO SHOW THE EFFECT UPON THE PROGENY OF TWO COLONIES OF *C. pennsylvanicus* WHOSE NURSES WERE FED WITH SALT-FREE DIETS

Colony	Nest Number	Diet	Average Weight Per Larva at Start in mgm.	Number of Pupae Produced	Average Weight Per Pupa in mgm.	Average Head Width of Progeny in Ocular Units	Standard Deviation of Head Widths
K	1	Basal	0.38 mgm.	59	7.94 mgm.	44 0	5 50
	2	"	0.50	48	8.53	44 4	9 42
L	3	"	0.37	21	16.74	49 0	8 34
K	4	Salt-Free	0.84	49	9.92	50 82	10 41
	5	"	0.40	47	11 08	49 32	11 84
L	6	"	0.32	26	16.09	51 47	10 77

ions provided by the salt mixture included in the basal diet, were harmful to the developing larvae. This harmful effect can hardly be attributed to the amount of the salt mixture included because it made up only 3% of the diet. This amount is less than the amount of a similar salt mixture other experimenters have used in insect nutrition work (Frobrich, G., 1939).

An experiment has been done which demonstrates the harmful character of a salt mixture, used to supply the mineral nutrients in a synthetic diet fed to colonies of *C. pennsylvanicus*. This salt mixture is known to be adequate for vertebrate animals, yet it was found to contain noxious substances when fed to the ants. More investigation is necessary upon insect requirements for mineral nutrients before it is possible to explain the harmful effect of the salt mixture.

Clearly, the amounts of such mineral nutrients required by colonies of *Camponotus* must be very minute, since the minerals present as impurities in a salt-free diet sufficed to produce good growth among the progeny of these ants.

### THE EFFECT OF A FAT-FREE DIET UPON THE PROGENY OF CAMPONOTUS COLONIES

The experiment about to be described sought to discover whether fats played an important role in the nutrition of any colonies. Two colonies, M and N were collected with their larvae and brought to the laboratory. 30 nurse ants were selected at random and placed in each of the Fielde nests as indicated in Table III. 95 larvae weighed as before, were given to the nurse ants already arranged in the nests.

TABLE III

DATA TO SHOW THE EFFECT UPON PROGENY OF TWO COLONIES OF  
*C. pennsylvanicus* FED A FAT-FREE DIET

Colony	Nest Number	Diet	Average Weight Per Larva at Start in mgm.	Number of Pupae Produced	Average Weight Per Pupa in mgm	Average Head Width of Progeny in Ocular Units	Standard Deviation of Head Widths
M	1	Basal	0.37 mgm.	27	9.14 mgm.	45 31	4 56
	2		0.38	34	8.91	44 34	5 24
N	3	"	0.70	42	9.80	46.1	10.74
M	4	Fat-free	0.43	41	9.71	45 23	5.08
	5		0.41	44	9.86	46 40	4 48
N	6	"	0.34	45	8.5	43.28	10 81

The ants in nests 1, 2 and 3 were fed the basal diet described above, and these nests served as controls for nests 4, 5 and 6 respectively. The ants in the latter nests were fed a diet similar to the basal diet except that it was rendered fat-free in the following way: the technical casein and yeast were separately washed 7 times with anhydrous ethyl-ether. The latter substance was selected because it was felt to be freer of impurities which might be left in the food and prove noxious to the ants. After this treatment both the ether-washed yeast and the ether-washed casein were then weighed in the amounts used in the basal diet, and these were added to the other ingredients of the diet. None of the fats used in the basal diet were added to this fat-free diet.

Inspection of Table III shows that the absence of fat from the diet of the nurse ants did not appreciably affect the progeny. The data shown in Table II indicates that colonies of *C. pennsylvanicus* are not sensitive to the absence of fat from an otherwise fully complemented diet. This finding is not surprising when we consider the meager fat requirements of insects in general (Melampy, R. M., 1937 and Trager, Wm., 1941). It is possible that a small amount of fat may still have remained in the casein and in the yeast even after numerous ether-washings. If such was the case, however, there must have been a very minute amount of fat remaining, and it is therefore evident that only minute amounts of fat, if any, are required by *Camponotus* colonies in rearing their brood.

### THE EFFECT OF A VITAMIN-FREE DIET UPON THE PROGENY OF CAMPONOTUS COLONIES

It was thought to be important to discover whether the absence of vitamins from the diet of *Camponotus* colonies might influence in any way the progeny which would result from colonies fed such a diet. For this purpose colony M was again used as a source for the nurse ants and larvae. 30 nurses were selected at random and placed in Fielde nests. 95 larvae were weighed as before and given to the ants.

A vitamin-free diet, similar to the basal diet was prepared by replacing the technical casein of the basal diet with vitamin-free casein.<sup>4</sup> No yeast was used in the vitamin-free diet thus prepared. The control nests were fed with the basal ration prepared as has been described above. It was assumed that the quality of the vitamin-free casein was not impaired by the removal of the vitamins.

The ants were given an abundance of food and distilled water and the experiment was continued for 68 days. Pupae were removed on their appearance in the nest and weighed immediately.

Table IV summarizes the results obtained from this treatment of a single colony of *Camponotus pennsylvanicus*.

TABLE IV  
DATA TO SHOW THE EFFECT UPON THE PROGENY OF A *C. pennsylvanicus*  
COLONY FED A VITAMIN-FREE DIET

Nest Number	Diet	Average Weight Per Larva at Start in mgm	Number of Pupae Produced	Average Weight Per in mgm. Pupa	Average Head Widths of Progeny in Ocular Units	Standard Deviation of Head Widths
1	Basal	0.37 mgm.	27	9.14 mgm.	45 31	4 56
2	"	0.38	34	8.91	44 34	5 24
3	Vitamin-free	0.40	18	7.35	41 58	4 22
4	"	0.38	21	7.80	42 61	3 56

From Table IV it may be seen that a vitamin-free diet proved to have a number of harmful effects upon the progeny of the colony. The pupae produced were fewer in number and were not as heavy, on the average, as were the pupae produced in nests whose nurses were supplied with a diet containing a full complement of vitamins. The average head width and hence the stature of the imagines was found to be greater when the diet was enriched with yeast. The standard deviation of the head widths was found also to be less in nests 3 and 4, whose nurses had been fed a vitamin-free diet.

It is clear from this experiment that the normal growth of the progeny in colonies of *C. pennsylvanicus* requires at least those vitamins which are supplied by Brewers' yeast. That the ants did as well as they

<sup>4</sup>Supplied through the courtesy of the Borden Company Laboratories, Bainbridge, N. Y.



did when fed a vitamin-free diet, must be attributed to the activity of the rich bacterial flora which is found in the gut both of the larvae and adult ants (Lilienstern, M., 1932). This bacterial flora must be held responsible for the elaboration of the vitamins necessary for the growth of the larvae in nests 3 and 4.

### SUMMARY

1. Experiments have been done which show that qualitative differences in the food given to colonies of *Camponotus herculeanus* subsp. *pennsylvanicus* DeGeer influence to a greater or less degree the stature, weight and number of progeny the colonies will produce.
2. Diets rich in protein have a deleterious effect upon the progeny.
3. A salt mixture which is known to be adequate for vertebrate animals is found to be harmful to ants.
4. The absence of fat from the diet of *Camponotus* colonies does not influence their progeny.
5. *Camponotus* colonies are sensitive to a vitamin deficient diet because the imagines produced are smaller in stature and fewer in number when the colonies are fed such a diet. It is concluded that the bacterial flora known to be present in the gut of the nurse ants and their larvae elaborates vitamins in sufficient quantity to permit larval development to proceed, albeit somewhat abnormally.

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INSECTS OF PORTO RICO AND THE VIRGIN ISLANDS, RHOPALOCERA OR BUTTERFLIES, by WILLIAM PHILLIPS COMSTOCK. New York Academy of Sciences, Scientific Survey of Porto Rico and the Virgin Islands, Vol. XII, Part 4, pp. 421-622, 29 figs., 12 plates, 1944. Price \$2.00.

The butterflies and skippers of the West Indies continue to be a tantalizing group because of the extensive insular variation. Comstock's thorough survey should be of great value in resolving the taxonomic problems of lepidopterists whose resources are not extensive. The publication does not key the genera and species, nor does it present descriptions of all species and subspecific units, but it abounds in critical analyses of difficult relationships and in descriptions of details, and includes many figures of neuration, a few of genitalia and excellent half-tone plates of the wings of many species. The typography and paper are excellent. Recognizing with the writer that the gaps in our knowledge of the insect fauna are staggering, we must feel that he will realize his hope of providing a stimulus to future workers on this fauna, and more than that, a contribution that will be a very real help.—A. W. L.

# THE RELATION OF HIND TIBIAE AND SENSORIA TO INTERMEDIACY IN PARTHENOGENETIC APHIDS

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Intergrades of various kinds as intersexes, intermediates and mosaics usually are considered abnormal individuals that occur sporadically as a result of an upset in the normal developmental pattern. To consider normal, regularly occurring animal forms intermediate or mosaic in the same sense as the abnormal forms are intermediate or mosaic may be incorrect, yet the winged and the wingless parthenogenetic female aphids may be so interpreted; and if this interpretation is the correct one it should result in a better understanding of the mechanism of aphid type production. It is the purpose of this paper to report the results of an investigation into the question of whether or not the normal parthenogenetic female aphids are in reality intermediate between males and gamic females.

The characters by means of which aphid types are distinguished can be classified into two groups, male and gamic female. Some of the characters associated with maleness are wings, wing muscles, ocelli, many antennal sensoria, thin hind tibiae and a male reproductive system. Gamic female characters include absence of wings, wing muscles, and ocelli, few antennal sensoria, hind tibia that are swollen, darkly colored and covered with hundreds of sensoria and a female reproductive system. Obviously these characters are found in either males or gamic females, but also some of them are found in the parthenogenetic females. For instance wings, wing muscles and ocelli are found not only in the males but also in winged parthenogenetic females. Likewise the absence of wings, wing muscles and ocelli is characteristic of both gamic and wingless parthenogenetic females. On the basis of such characters the aphid types can be placed in a series with the males and gamic females at the extremes and the parthenogenetic females in between. In this series the winged parthenogenetic females are close to the male type and the wingless parthenogenetic females are close to the gamic female type.

From the developmental point of view the expression of the differential characters in the four aphid types suggests that each embryo starts out in one of two directions, either toward the male extreme or toward the female extreme. If development is complete in either direction a male or gamic female results. However, if it is modified so that the expression of maleness or gamic femaleness is incomplete the parthenogenetic females are produced, and they will be either winged or wingless depending on whether the aphids complete development near the male or gamic female extreme.

The validity of this scheme of development can be checked in part by comparison of the differential structures in the aphid types to see if

the parthenogenetic females are in reality intermediate between the two gamic extremes. The characters chosen for this study are hind tibial size and number of antennal sensoria. These two characters were chosen because of their nature which permits careful measurement and comparison, and because males and gamic females differ decidedly in their expression.

It is known that gamic females have swollen hind tibiae and that males and parthenogenetic females have thin hind tibiae, but few actual measurements are on record and little is known of the actual size of parthenogenetic hind tibiae other than that they appear thinner than gamic hind tibiae. Shull (1930) noted the swollen condition of gamic female hind tibiae and also compared gamic females with parthenogenetic females with respect to hind tibial size. However, he used arbitrary comparative numbers instead of actual sizes, and furthermore clumped all parthenogenetic females together making no distinction between winged and wingless forms. Later (1931) using the same method he compared the hind tibiae of winged with wingless gamic-parthenogenetic female intermediates and found that the presence of wings is correlated with thin hind tibiae. Another mention of hind tibial size is made by Shull (1932) in comparing the gamic females of two clones. This time the measurements were made with an ocular micrometer but the length of the micrometer unit is not given, so except for two instances the figures again have comparative value only. The two exceptions are that in clone A the width is 4.3 per cent of the length and in clone B the width is 2.9 per cent of the length.

More adequate figures are available of the numbers of sensoria on the antennae. Shull (1925) finds 4 to 6 on wingless parthenogenetic females, 15 to 18 on winged parthenogenetic females, 4 to 8 on gamic females and 25 to 40 on males. Stiles (1938) agrees with Shull in finding 4 to 6 sensoria on wingless parthenogenetic females and 14 to 18 on winged females. He also lists a series of 199 counts on intermediate winged aphids. These figures were used by the author to compute the mean and standard deviation and are included in Table IV of this paper. Stiles (1939) concluded on the basis of his study of intermediates that sensoria number is very definitely related to the winged condition in aphids and he states that he found no closely graded series of sensoria number from one extreme to the other in the intermediates.

## MATERIAL AND METHODS

The aphids used in this study were taken from stock cultures of aphids grown on potato plants in the laboratory and killed by immersion in dioxane. The aphids were left in the dioxane until they could be transferred to slides and covered with balsam. The time in dioxane varied but never extended over a period of one week. Measurements were made of width and length on both right and left hind tibia, a filar micrometer being used for width and an ocular micrometer for length. The measurements were recorded in millimeters. Counts of antennal sensoria were made on both antennae with a compound microscope.

## HIND TIBIAL WIDTH

The means and standard deviations of the widths of aphid hind tibiae are given in Table I, an inspection of which shows that gamic females have the widest hind tibiae, the wingless parthenogenetic females the next widest, the winged females next while the males have the thinnest. The differences between all types are statistically significant.

A difference is considered significant when the difference between two means is a least twice the standard error of the difference between means.

TABLE I  
A COMPARISON OF HIND TIBIAL WIDTH MEASURED IN MILLIMETERS  
AT THE WIDEST PART

Type	n	Mean in mm.	Standard Deviation
Gamic Female. . . . .	199	076 $\pm$ 0004	006 $\pm$ 0003
Wingless Par. Female . . .	188	060 $\pm$ 0003	004 $\pm$ 0002
Winged Par. Female . . . .	199	048 $\pm$ 0002	003 $\pm$ 0001
Male. . . . .	195	040 $\pm$ 0002	003 $\pm$ 0002

## LENGTH OF HIND TIBIAE

The lengths of the hind tibiae also were measured and the results are given in Table II. The longest hind tibiae are found on wingless parthenogenetic females. The hind tibiae of winged parthenogenetic females are shorter and the difference is significant. In males and gamic females the hind tibiae are of the same length and are significantly shorter than either of the parthenogenetic types.

TABLE II  
LENGTH OF HIND TIBIAE IN MILLIMETERS

Type	n	Mean in mm.	Standard Deviation
Wingless Par. Female. . . .	200	2 62 $\pm$ 015	22 $\pm$ 01
Winged Par. Female. . . . .	203	2 44 $\pm$ 011	16 $\pm$ 007
Male. . . . .	196	2 0 $\pm$ 014	20 $\pm$ 01
Gamic Female. . . . .	199	2 01 $\pm$ 015	21 $\pm$ 01

## RATIO OF WIDTH TO LENGTH

The width of each hind tibia was divided by its length and the average w/l ratio computed. The results are given in Table III. The gamic females have the widest hind tibiae in relation to length. The wingless parthenogenetic females have the next widest while winged

parthenogenetic females and males have the same width. Both winged females and males have narrower hind tibiae than gamic females and wingless parthenogenetic females.

TABLE III  
RATIO OF WIDTH TO LENGTH OF HIND TIBIAE

Type	n	Mean in mm.	Standard Deviation
Gamic Female.....	197	.038 $\pm$ .0002	.003 $\pm$ .00015
Wingless Par. Female.....	187	.023 $\pm$ .0002	.002 $\pm$ .00012
Winged Par. Female.....	197	.0197 $\pm$ .0009	.001 $\pm$ .0006
Male.....	195	.0199 $\pm$ .001	.001 $\pm$ .0007

### ANTENNAL SENSORIA

A comparison of antennal sensoria numbers is given in Table IV. Gamic females have fewer sensoria than any of the other types with wingless females a close second. The difference between these two types of females is significant but small. Intermediate winged females have more sensoria than wingless females but fewer than winged females, while males have many more than any of the other types. All differences shown in Table IV are significant.

TABLE IV  
A COMPARISON OF ANTENNAL SENSORIA IN APHIDS

Type	n	Mean in mm.	Standard Deviation
Gamic Female.....	199	4.32 $\pm$ .09	1.27 $\pm$ .064
Wingless Par. Female.....	186	4.91 $\pm$ .076	1.04 $\pm$ .054
Intermediate Winged Female <sup>1</sup>	199	6.6 $\pm$ .143	2.02 $\pm$ .101
Winged Par. Female.....	200	15.33 $\pm$ .12	1.69 $\pm$ .084
Male.....	194	52.63 $\pm$ .57	7.94 $\pm$ .403

### DISCUSSION

The measurements of hind tibial width support the concept that the parthenogenetic females are intermediate between the gamic female type and the male. If absolute width is used as a criterion the wingless parthenogenetic females are similar to, but not quite like the gamic females. Likewise the winged females are similar to, but not quite like the males. If relative width is used the same relationship is found except that here the winged females and males are exactly the same. Presumably the length-width ratio represents a better expression of the

<sup>1</sup>Data taken from Stiles (1938).

relationship between the different types of tibia, in which case the winged females are mosaic for this character rather than intermediate. The character in wingless parthenogenetic females seemingly is intermediate.

The counts of antennal sensoria also indicate that parthenogenetic females may be considered intermediate between gamic females and males.

### SUMMARY

The measurements of hind tibial width and counts of antennal sensoria suggest that the expression of these characters in parthenogenetic females is intermediate between males and gamic females.

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STUDIES IN NEOTROPICAL MALLOPHAGA (III). TINAMIDAE No. 2, by M. A. CARRIKER, JR. Proceedings of the U. S. National Museum, No. 3180, Vol. 95, pp. 81-233; 29 figs. Washington, D. C., 1944.

Like so many entomological papers in the Proceedings of the United States National Museum, the third part of the Studies in Neotropical Mallophaga is a milestone in the taxonomy of the order. As a specialist in another order of insects who might possibly want to identify a few biting lice the reviewer notes the absence of keys as an unusual omission in such a comprehensive survey, but since insects of this order, and certainly of this family, are not likely to fall into the hands of entomological dilettantes, the omission can hardly be serious. The Studies are among the taxonomic contributions which take a permanent place in the intricate fabric of insect classification.—A. W. L.

STUDIES ON THE BIOLOGY OF THE WEBBING CLOTHES MOTH (*TINEOLA BISSELLIELLA* HUM.), by GRACE H. GRISWOLD. Cornell University Agricultural Experiment Station, Memoir 262, 59 pages, 24 figs. Ithaca, N. Y., 1944.

Detailed inquiry into the private life of household pests has apparently been an unattractive entomological adventure. The omission has been corrected here for *T. bisselliella* Hum., for this is decidedly a detailed inquiry, taking into consideration the effects of temperature, humidity and type of food on the mortality among these insects. In the painstaking procedures and extensive data it is an admirable biological study and should be most interesting as such. Since most of us are more concerned about discouraging than encouraging the little beasts, it leads to the facetious wish that fishmeal could be more abundant in our homes, to the mutual advantage of *bisselliella* and our clothing. And surely any inspiration to facetiousness denotes an interesting contribution.—A. W. L.

# EFFECT OF POTASSIUM FLUORIDE AND PYRETHRUM ON PERIPLANETA AMERICANA (L.) AFTER HEMO- CYTES ARE BLOCKED WITH CHINESE INK OR NEPHROCYTES ARE STAINED WITH TRYPAN BLUE

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The variation in insect resistance to insecticides is a common phenomenon observed in testing materials for toxicity. Environmental factors, such as temperature, humidity, and diet, have been found to affect resistance, but few attempts have been made to correlate it with physiological conditions within the insect. It is probable, however, that the effect of the environmental factors was to change the physiological state of the insect, which in turn determined its resistance.

One method of studying the physiological function of an organ or a tissue in an insect is to treat the insect with some material that will have a marked effect on that organ or tissue and little effect on the remaining cells. When such a treatment is followed by an application of insecticide, any change in resistance can be assumed to be related to the change in function of the organ or tissue affected by the original treatment.

Such a study was made by Yeager, McGovan, Munson, and Mayer (1942) with sodium arsenite and nicotine as the test insecticides. They injected carbon particles (Chinese ink) into large nymphs of the American cockroach (*Periplaneta americana* (L.)). Certain blood cells (hemocytes) in the roaches phagocytized these particles, and upon becoming filled these cells tended to stick together and form aggregates of cells, some of which, no doubt, lodged among the various tissues of the body and no longer circulated with the blood stream. The quantity of carbon particles injected was adjusted so that many blood cells appeared heavily loaded and very few, if any, carbon particles were seen floating free in the blood plasma. In other tests trypan blue, which stains the nephrocytes (pericardial cells), was injected into roaches, the quantity being adjusted so that these cells were deeply stained but the remaining tissues showed only traces of dye. Under such conditions, if these cells are partly responsible for the roaches' resistance to the insecticides and the carbon particles or the dye interfered with this function, the resistance of the roaches should decrease. Following this procedure Yeager *et al.* found that the carbon particles reduced the resistance of roaches to sodium arsenite to a marked degree and to nicotine to a slight degree, but that trypan blue did not change the resistance of roaches to either insecticide.

In the present investigation, which is a continuation of this work, solutions of potassium fluoride<sup>1</sup> in water or pyrethrum extract in acetone were applied to roaches that had been injected with Chinese ink or trypan blue.

## MATERIALS AND PROCEDURE

The technique employed in these tests was the same as that used by Yeager *et al.* The roaches were injected, at the rate of 0.01 ml. per gram of body weight, with (1) a suspension of Chinese ink in saline, (2) saline containing trypan blue, or (3) saline, and were confined individually in shell vials closed with screen wire. Approximately 24 hours after the injection the roaches were treated with acetone or acetone containing pyrethrum extract (0.4 mg. of pyrethrins per milliliter), or with water or water containing potassium fluoride, 0.30 gm. per milliliter for roaches injected with trypan blue and 0.35 gm. for the ink-injected roaches. These concentrations of potassium fluoride were used to obtain suitable levels of mortality.

The potassium fluoride and pyrethrum solutions were applied at rates of 0.0025 and 0.005 ml., respectively, per gram of body weight.

The solutions or carriers were placed between the wing pads and the body surface of the nymphs. The insects were observed daily for 14 days to determine the mortality. Each treatment was applied to three groups of roaches, approximately 10 insects being used in each test in the pyrethrum series and from 15 to 20 insects in the fluoride series.

The roach nymphs weighed from 455 to 1590 mg. each, with an average of 727 mg. The standard deviation of the distribution was 172 mg. Of the nymphs used, 52.4 per cent were males.

## RESULTS

The results obtained when roaches injected with carbon particles (Chinese ink) were treated with potassium fluoride are given in figure 1. On the 5th day after the insecticide was applied the mortality of the roaches injected with ink suspension was higher than that of roaches injected with saline without ink, but on the 14th day the reverse was true. This crossing of the mortality curves was confirmed in a second series of tests (not illustrated) with the same materials, although the general level of mortality was much lower. The significance of the differences in mortality of the poisoned insects given in figure 1 was determined by Student's method for the 5th and 14th days after application of the insecticide. There appeared to be no significant difference on the 5th day but an approach to the significance level (odds of approximately 17 to 1) on the 14th day. When the data from the second series of tests were combined with the data given in figure 1, a significant difference was found on both the 5th and 14th days. Observations on

<sup>1</sup>Potassium fluoride was used instead of the commonly used insecticide sodium fluoride, because its greater solubility in water allowed the preparation of a more concentrated solution so that the desired amount of insecticide could be applied in a smaller volume of water. A large volume of fluoride solution applied to the external surface of the roach might have resulted in considerable loss of material in some instances and possibly the ingestion of some of the poison.



the roaches in the second series were continued through the 35th day after treatment, but without significant change in the relative mortalities.

Following treatment with pyrethrum solution roaches injected with carbon particles showed some difference in total mortality, and greater difference in net mortality, from roaches not injected, but the differences were not statistically significant (fig. 3). The injection of trypan blue (figs. 2 and 4) had little effect, if any, on the resistance of the roaches to the insecticides applied.

TABLE I

EFFECT OF INJECTIONS OF CARBON PARTICLES (CHINESE INK) OR TRYPAN BLUE IN SALINE AND THE SUBSEQUENT EXTERNAL APPLICATION OF POTASSIUM FLUORIDE OR PYRETHRUM ON THE MOLTING AND MORTALITY OF *Periplaneta americana*

Treatment*	Percentage of Total Roaches That Molting	Per Cent Mortality Among Roaches That Molting	Per Cent Mortality Among Roaches That Did Not Molt
Carbon particles, trypan blue, or saline injected preceding external applications of—			
Potassium fluoride in water ..	16	86	41
Water.	24	21	1
Pyrethrum in acetone.	9	89	57
Acetone...	28	66	14
Water or acetone applied externally following injection with—			
Trypan blue in saline ..	30	40	7
Saline..	36	42	12
Carbon particles in saline....	19	58	7
Saline...	18	33	3

\*Each pair of treatments was applied to a single population of roaches, but different pairs were applied to different populations.

During the 14-day observation period any subnormality in the activity of the roaches when the vials containing them were shaken was recorded. These data show that the average period of subnormal activity preceding death was 2.2 days for the pyrethrum-treated roaches and 1.7 days for those treated with potassium fluoride.

In Table I are summarized the observations on the molting of the roaches. As molting would introduce another variable into the effect of the treatments, none of the results with roaches that molted are included in figures 1-4. During the observation period the percentage of roaches that molted in a single experiment ranged from 5 to 45, the average being 19.2 per cent. The insects molted from the first to the twelfth day after treatment. The average period from treatment to molting was

4.5 days for the insects that survived and 3.9 days for those that succumbed. The average period from molting to death was 1.75 days for roaches treated with potassium fluoride as compared with 2.5 days for similar unpoisoned insects. Pyrethrum-treated roaches succumbed 1.5 days after molting as compared with 2.0 days for unpoisoned roaches.

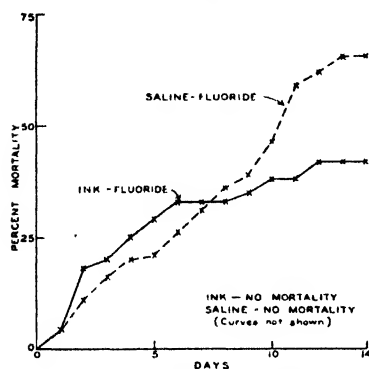


FIG 1-CHINESE INK - POTASSIUM FLUORIDE

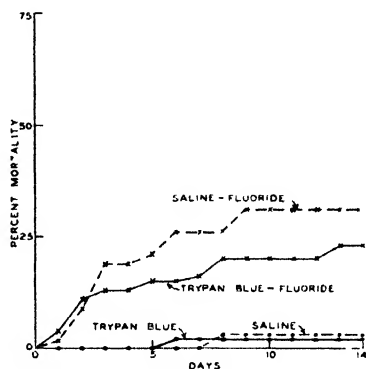


FIG 2-TRYPAN BLUE - POTASSIUM FLUORIDE

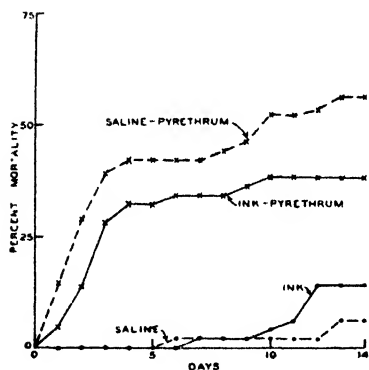


FIG 3-CHINESE INK - PYRETHRUM

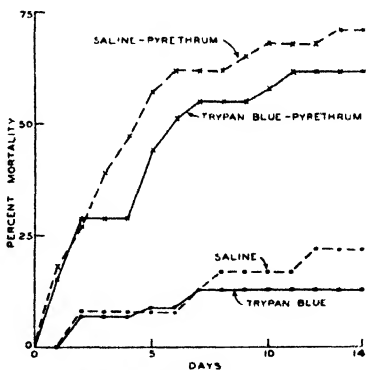


FIG 4-TRYPAN BLUE - PYRETHRUM

FIGS. 1-4. Effect of injections of Chinese ink or trypan blue on the mortality of *Periplaneta americana* subsequently treated externally with potassium fluoride or pyrethrum: Fig. 1, Chinese ink followed by potassium fluoride; fig. 2, trypan blue followed by potassium fluoride; fig. 3, Chinese ink followed by pyrethrum; fig. 4, trypan blue followed by pyrethrum.

## DISCUSSION

The crossing of the curves in figure 1 between the 7th and 8th days after the application of potassium fluoride indicates that the resistance of the roaches injected with carbon particles prior to poisoning was reduced during the first half of the observation period but was increased later in this period. The action of potassium fluoride was different from the action of pyrethrum (fig. 3) and also, as reported by Yeager

*et al.*, from that of sodium arsenite and nicotine. The results might have been due in part to the adsorption of some normal constituent or constituents of the plasma in the period between injection and phagocytosis of the carbon particles. However, if the carbon particles adsorbed the poisons, the latter must have first been taken up by the blood cells.

The injection of trypan blue in saline did not significantly change the resistance of the roaches to potassium fluoride or pyrethrum (figs. 2 and 4). These results are similar to the findings of Yeager *et al.* with sodium arsenite and nicotine. It will be noted that the mortality of the trypan blue-injected insects, both poisoned and unpoisoned, was only slightly below (not statistically significant) the mortality of the saline-injected roaches during the last 6 days, and also that the net mortality caused by the pyrethrum was the same in both trypan blue and saline-injected roaches.

Among the pyrethrum-treated insects (fig. 3) the mortality was higher throughout the 14-day period in those injected with saline alone than in those injected with ink in saline. This difference was not statistically significant, however; nor was the mortality of the unpoisoned roaches injected with ink in saline significantly higher than that among the unpoisoned ones injected with saline alone.

The curves in the different figures are not directly comparable, as the data were obtained at different times and on different lots of insects. It will be observed, however, that the level of mortality may have a marked influence on the shape of the curve. For example, in figure 1 the mortality of the insects injected with saline and subsequently treated with potassium fluoride continues to rise until the 13th day and then levels off after reaching 66 per cent. In figure 2 the mortality of roaches treated in a similar manner rises at approximately the same rate for 6 days, with another slight rise on the 9th day, and then levels off at 31 per cent. In other words, in this instance the low maximum kill was reached in much less time than the high.

The roaches that were treated with pyrethrum were affected within a few minutes and became very active, this activity being followed in most instances by partial or complete paralysis. However, the condition of the roaches was not recorded until 24 hours after treatment. By this time several of the roaches were dead, some appeared moderately or severely affected and died one or more days later, and the remainder had recovered or were slightly subnormal but returned to normal by the end of 48 hours. The effect of pyrethrum was different from that of nicotine (Yeager *et al.*), which caused a much more prolonged period of subnormality in many of the roaches.

Table I shows that under the conditions of these tests the mortality was considerably higher among the molting than the nonmolting roaches, and among the poisoned insects, whether they molted or not, than among the unpoisoned ones. These results also indicate that, in addition to their killing action, the insecticides may have inhibited molting in some cases. This effect appears slightly more pronounced among pyrethrum-treated roaches. The injection of ink or dye apparently did not inhibit molting. Trypan blue appeared to cause no mortality of roaches that molted, whereas carbon particles may have increased mortality.

## CONCLUSION

From the results previously reported by Yeager *et al.*, it appears that the injection of Chinese ink suspended in saline, which heavily loaded the hemocytes with carbon particles, caused a marked reduction in the resistance of the insects to sodium arsenite and probably slightly reduced their resistance to nicotine. In the present investigation, the same treatment reduced the resistance of the nymphs to potassium fluoride at some time during the first half of the observation period and increased their resistance by the end of this period; there was also a slight increase in resistance to pyrethrum. It seems evident that the injection of the Chinese ink in saline changed the physiological state of the insects in such a manner that they reacted anomalously to all the poisons applied, especially the inorganic poisons. When a solution of trypan blue in saline was injected into the roaches, however, it stained the nephrocytes blue but did not appreciably change the resistance of the insects to either the organic or inorganic poisons.

## SUMMARY

Nymphs of the American cockroach (*Periplaneta americana* (L.)) were injected with carbon particles (Chinese ink) or trypan blue in saline and then poisoned by the external application of potassium fluoride in water or pyrethrum in acetone, to determine if the injections affected the resistance of the roaches to the poisons. The injection of carbon particles lowered the resistance to potassium fluoride for a time during the first half of the observation period but caused a marked rise in resistance by the end of the period. The injection of carbon particles appeared to increase the resistance of the roaches to pyrethrum slightly, but the difference was not statistically significant. The injection of trypan blue apparently did not change the resistance of the roaches to potassium fluoride or pyrethrum. Some observations on activity and molting are given and discussed.

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CHECKLIST OF THE COLEOPTEROUS INSECTS OF MEXICO, CENTRAL AMERICA, THE WEST INDIES, AND SOUTH AMERICA, PART 2, by RICHARD E. BLACKWELDER. United States National Museum, Bulletin 185, 341 pages, Washington, D. C., 1944. For sale by the Superintendent of Documents, Washington, D. C. Price \$0.30.

The format of National Museum publications is too familiar to scientists to require comment and the extremely useful but equally prosaic nature of checklists offers no meat to a reviewer. One can only notice this second part of Blackwelder's checklist as an extremely helpful addition to the literature on the Coleoptera of the New World with the gratitude that should go to specialists who give their time to such work when it might better serve their own interests in other studies.—A. W. L.

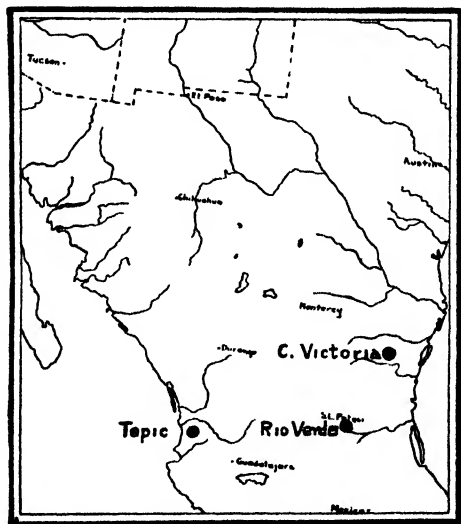
# ELEVEN NEW SPECIES OF EURYTOMA FROM MEXICO (Eurytomidae: Hymen.)

## PARTS III AND IV. BREVIURA AND AUREATA GROUPS

ROBERT E. BUGBEE,<sup>1</sup>

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In two preceding papers eleven new species of the genus *Eurytoma* were described from Mexico. The first paper dealt with 5 new species of the so-called Mucronura group (Bugbee, 1941a) and the second with 6 new species of the Atrateges group (Bugbee, 1941b). To conform with the others, the new species described herein are assigned to the Breviura and Aureata groups. No description or nomenclatorial



MAP No. 1. Type localities of species of *Eurytoma*, Aureata Group.

standing has been given these four groups, as their correct status cannot be finally determined until all the North American species of the genus *Eurytoma* are studied and the genus revised. However, they are quite distinct as far as the Mexican material is concerned. It is probable that all four groups may extend into the southern part of the United States.

<sup>1</sup>Contribution No. 45 from the Zoology Department of Fort Hays, Kansas, State College, Hays, Kansas.

The new species of the *Breviura* group were bred from galls belonging to the cynipid genus, *Disholcaspis*. The host galls were collected in the fall of 1931 by Dr. A. C. Kinsey in the Western Sierra mountain range of Mexico (Map No. 1).

A check of these parasites has failed to reveal the same degree of close correlation with the host species below the generic level that was found, for instance, in the species of the *Mucronura* group. Although all the new species of *Eurytoma* of the *Breviura* group described in the following pages were bred from *Disholcaspis* galls, close relatives among



MAP No. 2. Type localities of nine new species of the genus *Eurytoma*, *Breviura* Group.

the parasites were bred from *Disholcaspis* galls placed in unrelated complexes. Furthermore, the nine new species of the *Breviura* group show evidence, as noted in connection with their descriptions, of representing at least five different complexes which do not coincide with the complexes indicated by Dr. Kinsey for the *Disholcaspis* hosts. This might seem contradictory but it has been pointed out before (Bugbee, 1941a) that sometimes parasites show close correlation with their hosts, i. e., one species of parasite occurs on one species of host or on several closely related species of hosts, while in other cases a parasite

may attack several unrelated species of hosts belonging, even, to different orders. Here, at least, the nine species are confined to the single genus (*Disholcaspis*) even though they do not carry the relationship through to the complexes. After careful consideration it is believed that this apparent contradiction may not be valid. Two possible explanations may be considered: (1) The species of *Eurytoma* may be parasitic on inquilines or on other species of primary parasites of the gall-making species and will show closer correlation with them than with the true gall-maker. (2) The species of *Eurytoma* may be primary parasites of the gall-making host species but have not developed as close a correlation with their hosts as the more specialized species of the *Atrateges* and *Mucronura* groups. Students of insect phylogeny have held that extreme host restriction represents a high degree of specialization, and it is found to occur most often in species of relatively recent origin. Conversely, generalized host relationships occur most often among species representing older evolutionary stock from which the more recent, specialized species may have arisen. In this case, the fact that the species of the *Breviura* group fail to show as close a correlation with the hosts as in the other two groups, may mean that they represent more generalized stock and are thus not as highly specialized in their host relationships as the species of the *Mucronura* and the *Atrateges* groups.

Correlated with the more generalized host preferences is a greater degree of structural differences between the species of the *Breviura* group which makes them more distinct and easier to separate than the species of either the *Atrateges* or *Mucronura* groups. This greater degree of structural modification in addition to the generalized host relationship suggests that the second explanation offered above seems to be the more likely. If life-history studies can be made some day, additional evidence for or against this hypothesis may be uncovered.

The difficulties which would have to be overcome in working out the life-histories of the parasites would be much the same as those outlined by Dr. Kinsey (1942, page 167) in working out the life-histories of the gall-makers.

It should be emphasized here that the citation of the host gall-making species after each description of the species of *Eurytoma* merely means that the species of *Eurytoma* was bred from galls of that host species but does not mean that the species of *Eurytoma* were necessarily parasitic on the gall-making species. The species of *Eurytoma*, instead of parasitizing the gall-making species, may have been parasitic on other species of primary parasites or inquilines belonging to different families or even orders.

The *Breviura* group may be told from the *Mucronura*, *Atrateges* and *Aureata* groups by the very short, stubby, exposed tip of the dorsal valves; the short postmarginal vein which is usually one-half or less the length of the marginal; the lack of noticeable lateral compression of the abdomen; the relatively weakly developed genitalia with no tendency to coil upon itself in most of the species, brown tegulac, and the different host relationships.

The descriptions of the new species follow:

## BREVIURA GROUP

## PART III

*Eurytoma breviura*, n. sp

(Plate I, figs. 1 and 5)

*Female*.—Length, 2.5–4.3 mm.; average 3.6 mm. Abdomen oval to rectangular from the side; no great dorsal extension, anteriorly, so that the dorsal outline of the abdomen slopes gradually backward and then drops abruptly to the level of the protruding tips of the genitalia; depth averages 1 mm. (range .80–1.2 mm.) and the width, from above, .75 mm. (range .50–.90 mm.); fine scaling on lateral aspect of segment 6 somewhat reduced, covering only about one-third to one-half of the lower surface; plays out dorsally and reaches posterior edge of segment only towards base; exposed tips of dorsal valves short and stubby; genitalia averages in length 1.8 mm. (range 1.7–1.8 mm.) and in height 1.1 mm. (range 1.1–1.2 mm.); dorsal and ventral valves turn dorsally anteriorly but there is no tendency for ventral valves to bend posteriorly; vertical dimension of dorsal valves may be about same width for horizontal length (range .15–.30 mm., average .22 mm.); angle formed by the horizontal and tangent lines --39 degrees; tips of ventral valves brown; stylet arch halfway between a horizontal and vertical plane; (See Plate I, fig. 1). Legs with the coxae black; black infuscation on most femurs; occasionally lacking on front-femurs; black appears as spots on outer face of fore- and mid-femurs; encircles middle of hind-femurs, covering all but tips; black infuscation in middle of hind and mid-tibiae and on front-tibiae of some. Thorax with the tegulae brown. Propodeum with a shallow median depression, down the middle of which is a ridge which is quite distinct dorsally but practically obliterated ventrally; ridges marking lateral edges of depression indistinct; short irregular lateral ridges extend from central ridge; at top of central ridge are two large oval areas, one on each side of central ridge; above these is a shallow crescent-shaped pit; at base of median depression is a round, deep pit; median depression about same width for whole length. Head with a deep triangular pit under the eye. Antennae with basal half of the scape brown; rest black. Wings average in length 3.3 mm. (range 3.2–3.6 mm.); veins brown; heavy and distinct; postmarginal vein, which averages .20 mm. (range .17–.22 mm.) in length, less than half as long as the marginal, which averages .43 mm. (range .37–.50 mm.) in length; postmarginal truncate at outer tip; stigmal club rectangular and with a rounded base. Wing-body ratio of 1.09.

*Male*.—Length, 2 to 3.6 mm.; average 2.8 mm. The males are quite variable; in some the tegulae are black and in others brown. In wing characteristics they all fit into this complex as well as this species. The wing veins are dark brown and heavy; postmarginal vein is less than half the length of the marginal; postmarginal averages .20 mm. (range .10–.27 mm.) in length and the marginal .41 mm. (range .32–.47 mm.). Black infuscation on the legs of those with black tegulae is more extensive than those with brown tegulae.



occurring on all tibiae and femurs; increasing from front to rear. Males with brown tegulae have no black infuscation appearing on the fore-legs but usually some is present on mid-femurs, hind-femurs and tibiae.

*Types*.—31 females and 16 males; holotype female and allotype male as well as paratypes of both sexes in the Bugbee collection, Hays, Kansas.

*Type Locality*.—Labels read, Jilotepec, 7 miles northwest, State of Mexico, Mexico; elevation 9500 feet; galls collected January 16, 1932; males and females emerged spring of 1932; also a second batch of males and females that emerged the spring of 1933 to as late as July 20, 1933.

*Host*.—Labels read, from galls of an undescribed species related to *Disholcaspis bassettii*, Kinsey det., on *Quercus purpusi*, Kinsey coll.

*Range*.—Known only from the type locality (Jilotepec).

This species seems to resemble the next species more than any of the others. It differs from it, however, in the wing-body ratio, relation of the length of the marginal and postmarginal veins, coloration of the legs, host relationships, and shows an incomplete central ridge down the center of the propodeum.

The polymorphism of the males as displayed in the black and brown tegulae is interesting. At first the males with the black tegulae were considered to belong to a distinct species as well as a distinct group, but in most of their other characteristics they resembled the *Breviura* group and fell within the limits of this species. The presence of the black tegulae in this case may represent a mutation and suggests a possible origin of this character as it appears in the *Atrateges* group (Bugbee, 1941b). It may also imply that the *Atrateges* and *Breviura* groups are closely related. At any rate it shows that so-called diagnostic characters cannot be relied upon in one hundred per cent of the cases. It is interesting to note further that all the black tegulae males emerged the first spring (1932) while two of the brown tegulae males emerged in the spring of 1932 and the rest in the spring of 1933. The black tegulae males may represent offspring from eggs laid by a single, unfertilized female.

In common with other species of this genus, i.e., *E. rhois* (Bugbee, 1939), *E. fulva* (Bugbee, 1941b), etc., this species exhibits a record of emergence over a two-year period (1932 and 1933).

### ***Eurytoma linearis*, n. sp.**

(Plate I, fig. 2)

*Female*.—Length, 2.8–3.9 mm.; average 3.5 mm. Abdomen rectangular in general outline from a lateral view; no great dorsal arching of anterior part of the abdomen; depth from the side averages 1.1 mm. (range .85–1.1 mm.) and width from above averages .80 mm. (range .60–.87 mm.); exposed tips of the dorsal valves short and stubby; average .12 mm. (range .10–.15 mm.) in length. Genitalia averages 1.7 mm. in length and in height 1.4 mm.; dorsal valves turn dorsally, anteriorly; ventral valves turn dorsally also but show no tendency to bend posteriorly; stylet arch about halfway between a vertical and a horizontal plane; dorsal valves narrow for horizontal

length averaging .15 mm.; angle formed by the horizontal and tangent lines—45 degrees; extreme outer tip of ventral valves black. Legs with the main basic color brown; black infuscation most often on all femurs; occurs as spots on fore- and mid-femurs, but covers most of hind-femur; tibiae usually with no black; occasionally a small amount on hind-tibiae; tips of femurs and tibiae brown to lemon yellow. Tegulae brown. Propodeum with a central ridge down middle of median depression; depression divided unequally by faint lateral ridges emanating from central ridge; spaces between lateral ridges appear smooth and shiny; at base of central ridge is a large, rectangular depression surrounded by a distinct ridge; at top of ridge is a very shallow indistinct pit; whole central depression about same width for entire length. Head with the eyes not bulgy laterally and quite flat across the front. Antennae with the basal half of the scape yellow; rest black. Wings average in length, 2.6 mm. (range 2.0–3.0 mm.); veins yellow and thin; postmarginal vein about one-half or more length of the marginal; postmarginal averages in length .25 mm. (range .22–.27 mm.) and the marginal .40 mm. (range .40–.42 mm.); stigmal club shallow and very slightly rounded basally. Wing-body ratio of 1.34.

*Male*.—Average length is 2.75 mm. Coxae black; black on hind-femurs and tibiae; slight amount on mid-femurs and tibiae; none on front-femurs and tibiae. Scape yellow only on lower one-fourth or less; rest black. Wing veins dark brown.

*Types*.—6 females and 2 males; female holotype and allotype male along with paratypes of both sexes in Bugbee collection, Hays, Kansas.

*Type Locality*.—Labels read, Morelia, 14 miles east, State of Michoacan, Mexico, 7000 feet altitude; galls collected December 27, 1931; males and females emerged spring of 1932.

*Host*.—Labels read, from galls of an undetermined species of the *Disholcaspis perniciosus* complex, Kinsey det., on *Quercus conglomerata*, Kinsey coll.

*Range*.—Known only from Morelia, in the central part of the State of Michoacan.

This species is closely related to the preceding species (*E. breviura*). It may be distinguished from *E. breviura*, however, by the presence of less black infuscation on the legs, longer postmarginal vein in relation to the length of the marginal, wing-body ratio, and host relationships.

### *Eurytoma lata*, n. sp.

*Female*.—Length, 3.2 to 3.6 mm.; average 3.4 mm. Abdomen oval from a lateral view; width equals .75 mm. (range .70–.87 mm.) and depth 1.0 mm. (range .90–1.1 mm.); exposed tip of dorsal valves short and stubby, averaging .15 mm. (range .12–.17 mm.) in length; a few (3–6) short white hairs occur on the latero-dorsal aspect of segment 6; fine pitting on segment 6, laterally, somewhat reduced; covers one-half or less of surface. Genitalia with the dorsal valves wide for horizontal length giving them a very stout appearance (average .25 mm.); whole structure averages 1.4 mm. in length and .9 mm. in height; dorsal valves turn only slightly dorsally, anteriorly;

ventral valves turn dorsally but do not tend to bend back on themselves; angle formed by the horizontal and tangent lines—38 degrees; stylet arch halfway between a vertical and a horizontal plane; much less dorsal curvature of both valves than in other species of this group with the exception of *E. levidensis*. Legs with the coxae black; femurs may be all yellowish brown or may show varying amounts of black infuscation; in most cases front and mid-femurs are brown and hind-femurs shows a splotch of black medially; tibiae in most cases all yellowish brown; in a few cases black infuscation may appear on mid and hind-tibiae. Tegulae brown. Propodeum with a shallow median depression; wider at top than at bottom; central ridge extends about halfway down center of depression; below where central ridge plays out depression divided by several horizontal ridges into small rectangular areas; at base of depression is a deep rectangular pit much wider than base of depression; at top of depression on each side of central ridge are two large shiny rectangular areas. Head with an indication of a shallow pit below eye. Wings average in length 2.7 mm. (range 2.5–2.8 mm.); veins light brown in color; heavy; postmarginal vein averages .17 mm. (range .12–.20 mm.) in length and the marginal .35 mm. (range .32–.37 mm.); thus the postmarginal is about half the length of the marginal; stigmal club tends to be more nearly square than rectangular and basally it is rounded. Wing-body ratio of 1.25.

*Male*.—No males are known.

*Types*.—6 females; female holotype and paratypes in the Bugbee collection, Hays, Kansas.

*Type Locality*.—Labels read, Atequiza, five miles east; State of Jalisco, Mexico; altitude 6500 feet; galls collected on December 12, 1931; females emerged July 15, 1932.

*Host*.—Labels read, from an undescribed species belonging to the *Disholcaspis sulcatus* complex, Kinsey det.; on *Quercus laxa*, Kinsey coll.

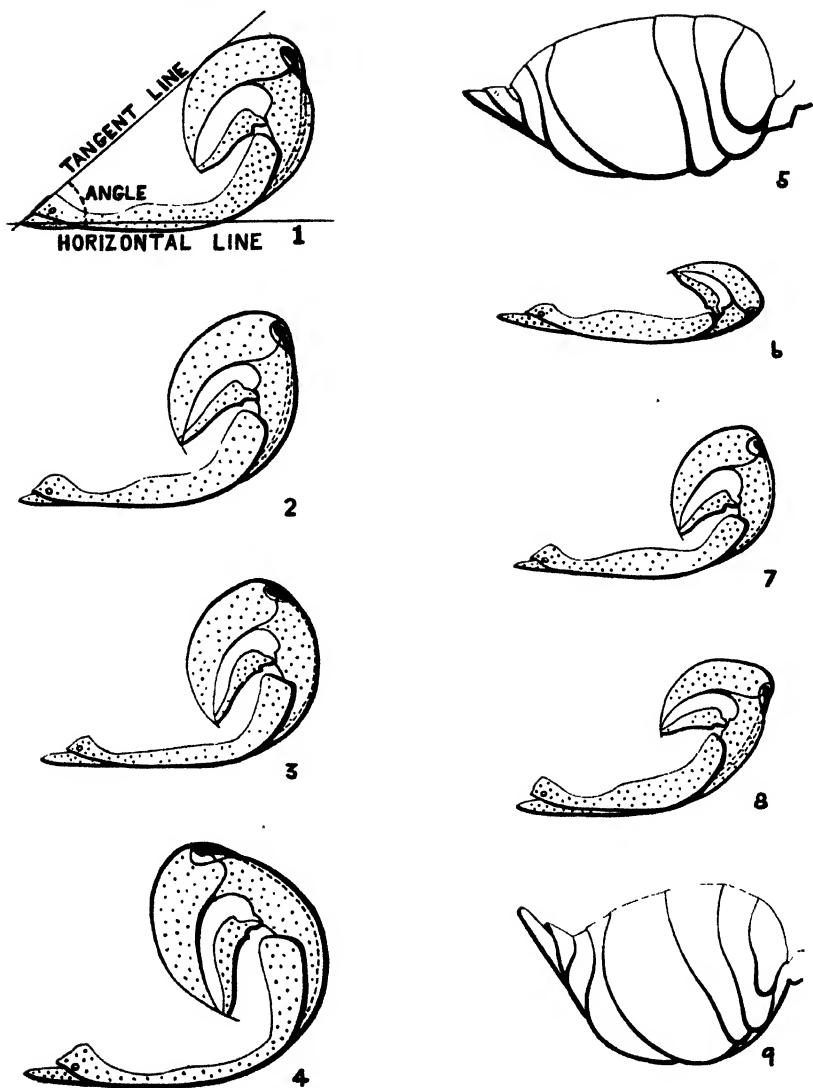
*Range*.—Known only from the type locality.

*E. lala* resembles the preceding material from Jilotepec and Morelia more than any of the other new species. It can be separated from them by its shorter marginal and postmarginal veins, smaller and stouter appearing genitalia, and the different host relationships.

### ***Eurytoma imago*, n. sp.**

(Plate I, fig. 3)

*Female*.—Length 2.5 to 3.3 mm.; average 2.9 mm. Abdomen black, oval to rectangular in outline from lateral view; no great dorsal arching of the anterior part of the abdomen; depth averages .85 mm. (range .75–1 mm.); width .60 mm. (range .55–.70 mm.); fine scaling on lateral aspect of segment 6 prominent basally and covering about one-half to three-fourths of surface; segment 6 averages at widest point .50 mm. and is wider than segments 4 and 5 combined, which average .40 mm.; exposed tip of dorsal valves short; genitalia averages in length 1.4 mm. (range 1.3–1.5 mm.) and in height .95 mm. (range .90–1 mm.); both dorsal and ventral valves turn dorsally, anteriorly, and stylet arch is close to a vertical plane; dorsal valves



Genitalia and Abdomens of New Species of the genus *Eurytoma* from Mexico (Breviura Group):

FIG. 1. Female genitalia of *Eurytoma breviura*, showing angle used in descriptions. 2. Female genitalia of *Eurytoma linearis*. 3. Female genitalia of *Eurytoma imago*. 4. Female genitalia of *Eurytoma excellens*. 5. Female abdomen of *Eurytoma breviura*. 6. Female genitalia of *Eurytoma levidensis*. 7. Female genitalia of *Eurytoma venula*. 8. Female genitalia of *Eurytoma subfusca*. 9. Female abdomen of *Eurytoma excellens*.

extremely narrow for all of horizontal length, averaging .12 mm.; angle formed by horizontal and tangent lines—45 degrees; tips of ventral valves light brown. Legs with the coxae black; black infuscation on all femurs becoming progressively greater in amount from front to rear; black also on all tibiae; tips of femurs and tibiae, brown to lemon yellow. Thorax with the tegulae brown. Propodeum with a fine barely discernible central ridge extending down middle of slight median depression; indications of short lateral ridges extending from central ridge; spaces between lateral ridges smooth and shiny; at top and bottom of central ridge are shallow pits which do not appear divided. Antennal joints appear to be moniliform; scape black for upper two-thirds; rest yellow. Wings average in length 2.3 mm. (range 1.8–2.5 mm.); veins light yellow; marginal vein longer, averaging .30 mm. (range .25–.35 mm.), than the postmarginal, which averages .15 mm. (range .15–.17 mm.) in length; stigmal club small, rectangular with rounded base; wing-body ratio of 1.26.

*Male*.—Length, 1.9 to 2.6 mm.; average 2.2 mm. Specimens too poor for further description.

*Types*.—13 females and 5 males; holotype female and allotype male along with paratypes of both sexes in the Bugbee collection, Hays, Kansas.

*Type Locality*.—Labels read, Matachic, 3 miles north, State of Chihuahua, Mexico; altitude 6700 feet; galls collected on October 21, 1931; males and females emerged, spring of 1932.

*Host*.—Labels read, from galls of *Disholcaspis (perniciosa) punicea* (Kinsey MS.) Kinsey det., on *Quercus chihuahuensis*, Kinsey coll.

*Range*.—Known only from Matachic in the west, central part of the State of Chihuahua. Probably extends north and south of Matachic along the mountains.

This species seems to have many characteristics in common with the preceding group of three species, all of which occur far to the south. This may be accounted for by the collecting which failed to obtain closely related material in between Atequiza and Matachic. In all probability as more material comes out of Mexico this gap will be filled in.

*E. imago* may be distinguished by its smaller size, short marginal and postmarginal veins, propodeal sculpturing and presence of black infuscation on all femurs and tibiae.

*E. imago* and the three preceding species make up a group that have much in common. Under ordinary circumstances they would be placed in a complex by themselves apart from the other species described herein. The complex is not given a name, however, as additional material and study are needed before the relationships of the *Breviura* group can be definitely determined.

### ***Eurytoma levidensis*, n. sp.**

(Plate I, fig. 6)

*Female*.—Length ranges from 3.0 to 3.4 mm.; average 3.2 mm. Abdomen rectangular from a lateral view and plump; no great dorsal extension anteriorly so that dorsal surface of abdomen slopes gently posteriorly and then drops abruptly to level of exposed tips of

genitalia; width from above averages .75 mm. and depth from the side .94 mm.; exposed tip of dorsal valves short; averages .12 mm. in length; scaling on lateral aspect of 6th segment covers about one-half of segment. Genitalia averages 1.5 mm. in length and .55 mm. in height; practically no dorsal extension of valves anteriorly; dorsal valves from the side wide for horizontal length, averaging .27 mm. and from a dorsal view widely spread; angle formed by the horizontal and tangent lines—23 degrees; arch of the stylets in a horizontal plane rather than a vertical plane. Legs with the coxae black; black on all femurs; covers all but lemon yellow outer tip on hind-femurs; most of mid-femurs also and flares up on front-femurs to cover three-fourths or more; black on all tibiae becoming progressively greater in amount from front to rear. Thorax with the tegulae brown. Propodeum with a shallow median depression divided down middle by a central ridge which plays out halfway down; below central ridge are usually two rectangular areas separated by horizontal ridges; at top on either side of central ridge are two oval shiny areas; at base of median depression is a deep rectangular pit; dorsal part of whole median depression more depressed than ventral part. Antennae with the scape all black; joints tend to appear moniliform. Wings average in length 2.7 mm.; veins light lemon yellow; postmarginal vein less than one-half length of marginal; postmarginal averages .17 mm. (range .15-.20 mm.) and marginal .39 mm. (range .35-.42 mm.); stigmal club rectangular and tends to be flat basally. Wing-body ratio 1.18.

*Male*.—Length 2.5 mm.; wing veins heavy and dark brown in color.

*Types*.—5 females and 1 male; holotype female and allotype male along with paratype females in Bugbee collection, Hays, Kansas.

*Type Locality*.—Labels read, Querétaro, 28 miles north, State of Querétaro, Mexico; elevation 7300 feet; galls collected on January 17, 1932; males and females emerged on July 25, 1932.

*Host*.—Labels read, from galls of an undescribed species of the *Disholcaspis fungiformis* complex, Kinsey det., on *Quercus chihuahuensis*, Kinsey coll.

*Range*.—Known only from the type locality.

This species approaches the four preceding species in several characteristics: (length of the marginal and postmarginal veins, wing-body ratio, propodeal sculpturing, size and general proportions). It can be separated from them by its quite differently shaped genitalia, which shows practically no dorsal extension of the valves anteriorly, as well as the stoutness of the dorsal valves. In addition the presence of black infuscation on all femurs and tibiae of the legs will help to distinguish it.

On the basis of the distinct genitalia this species could be placed in a separate complex from the four preceding species. More material must be obtained and studied before its exact relationships can be determined.

### *Eurytoma spadix*, n. sp.

*Female*.—Length 2 to 4 mm.; average 3.7 mm. Abdomen deeply oval to triangular from a lateral view; considerable dorsal arching

of the anterior part of the abdomen; depth from the side averages 1.2 mm.; width from above .85 mm.; fine scaling on lateral aspect of segment 6 covers one-half to three-fourths of surface; tips of ventral valves yellowish brown; tip of dorsal valves short and stubby. Genitalia averages 2. mm. in length and 1.4 mm. in height; dorsal valves wide for horizontal length, averaging .32 mm., and they turn abruptly dorsally, anteriorly; ventral valves turn dorsally also and then tend to bend backwards as though coiling up on themselves; angle formed by horizontal and tangent lines—43 degrees; stylet arch in a vertical plane. Legs with the coxae black; except front-coxae which may show yellowish tinge on inner surface; femurs most often brown with outer tips becoming lemon yellow; if black infuscation is present at all it appears on middle of hind-femurs only; tarsi white. Tegulae brown. Propodeum with a median depression down middle of which runs a straight central ridge; small ridges radiate laterally from central ridge across median depression; between lateral ridges finely shagreened; at top of central ridge is a deep gently curved pit; below pit on each side of central ridge are two large smooth shallow depressions; at base of central ridge are two deep pits or foveae; whole median depression wider at top than at bottom. Antennae with the scape yellow for lower half; rest black. Wings average in length 3.1 mm. (range 2.9–3.6 mm.); veins dark brown to straw yellow; marginal slightly more than twice as long as the postmarginal; marginal averages in length .38 mm. and postmarginal .17 mm.; stigmal club rectangular with rounded base. Wing-body ratio of 1.2.

*Male*.—Length 2.5 to 3.5 mm.; average 3. mm. Legs with most femurs and tibiae deep reddish brown; in a few slight black infuscation may appear on hind-femurs, hind-tibiae or mid-tibiae; front-coxae in most specimens all yellow; in a few basal half may be black and rest yellow; mid and hind-coxae black. Wing veins dark brown.

*Types*.—11 females and 17 males; holotype female and allotype male along with paratypes of both sexes in the Bugbee collection, Hays, Kansas.

*Type Locality*.—Labels read, Villa Campos, 21 miles south, State of Durango, Mexico; 6700 feet altitude; galls collected on October 30, 1931; males and females emerged in the spring of 1932.

*Host*.—Labels read, from galls of *Disholcaspis (perniciosa) quadrata* (Kinsey MS.), Kinsey det., on *Quercus undata*, Kinsey coll.

*Range*.—Known only from Villa Campos in the Western Sierra of Mexico.

This species is closely related to the next species (*E. venula*) from Canatlan, which lies to the south of Villa Campos. Both were bred from galls of the species of the genus *Disholcaspis* which occurred on the same oak host (*Quercus undata*). The two species of *Eurytoma* are about the same in average length and proportions, color of the legs and in the shape and sculpturing of the propodeum. On such a basis they could be placed in a distinct complex apart from the other species described herein.

The two species concerned here (*E. spadix* and *E. venula*) are easily

separated from one another by the following characteristics: shorter marginal vein in *E. spadix*; the fact that in *E. venula* the marginal is more than three times as long as the postmarginal, while in *E. spadix* the marginal is about twice as long as the postmarginal; the total lack of any black infuscation on any of the legs and the shorter less dorsally produced genitalia in *E. venula*. If males are available the yellow fore-coxae of *E. spadix* males in contrast to the black fore-coxae of the males of *E. venula* is a good characteristic.

Here, as in the group of five species preceding, we find that although *E. spadix* and *E. venula* are closely related structurally and occur in neighboring territories they were, nevertheless, bred from host species of different complexes, i.e., the *perniciosa* and *sulcatus* complexes. This is true of this whole group of new species as mentioned in the introduction. Apparently close correlation with the host does not go beyond the genus.

***Eurytoma venula*, n. sp.**

(Plate I, fig. 7)

*Female*.—Length, 3.2 to 4.2 mm.; average 3.7 mm. Abdomen oval to rectilinear in shape from the side; scaling on lateral aspect of segment 6 covers about lower half of surface; anterior part of the abdomen extended dorsally more than in other species of this genus with the exception of *E. spadix*; depth averages 1.1 mm. and width from above .9 mm.; tip of dorsal valves short and stubby. Genitalia averages in length 1.7 mm. and in height 1.2 mm.; both dorsal and ventral valves turn dorsally but ventral valves do not tend to coil up on themselves; dorsal valves narrow (average .15 mm.) for horizontal length; angle formed by horizontal and tangent lines—42 degrees; stylet arch oblique. Legs with the coxae black; all femurs deep reddish brown in middle shading to lemon yellow tips; same is true for the tibiae; no black infuscation appears at all. Propodeum with a narrow median depression which is slightly wider at top than bottom; central ridge down center of depression from which radiate small lateral ridges dividing depression into series of small squares on each side of central ridge; at top of depression on each side of central ridge are two large oval areas; at base of depression are two triangular pits. Antennae with the scape yellow on lower half; rest black. Wings average in length 2.8 mm.; veins brown; marginal vein very long in relation to the postmarginal; actually marginal more than three times length of postmarginal; marginal averages .47 mm. (range .45–.50 mm.) and postmarginal .15 mm. (range .12–.17 mm.) in length; stigmal club rectangular to almost square and rounded basally. Wing-body ratio of 1.30.

*Male*.—Length, 2.1 to 3.2 mm.; average 2.8 mm. Legs with the coxae black; black infuscation on middle of hind-femurs; tips lemon yellow; other femurs mostly all yellowish brown; tibiae yellow brown except hind-tibiae which may show a slight trace of black medially.

*Types*.—5 females and 5 males; holotype female and allotype male along with paratypes of both sexes in the Bugbee collection, Hays, Kansas.



*Type Locality*.—Labels read, Canatlan, 7 miles north, State of Durango, Mexico; elevation 7400 feet; galls collected on November 9, 1931; males and females emerged in the spring of 1932.

*Host*.—Labels read, from galls of an undescribed species of the *Disholcaspis sulcatus* complex, Kinsey det., on *Quercus undata*, Kinsey coll.

■ *Range*.—Known only from Canatlan in the Western Sierra of the State of Durango.

*E. venula* has its closest relative in *E. spadix*. The similarities and differences between the species are listed under the description of *E. spadix*.

### **Eurytoma subfusca, n. sp.**

(Plate I, fig. 8)

*Female*.—Length ranges from 2.6 to 3.6 mm.; average 2.9 mm. Abdomen globular in outline from the side; quite plump; depth from the side averages 1.1 mm. (range 1–1.2 mm.); width from above .85 mm. (range .80–1 mm.); white pile on segments 7, 8, and 9 quite sparse and short; lateral surface of segment 6 heavily scaled or pitted; covers about three-fourths of whole surface; exposed tip of dorsal valves very short and blunt; genitalia averages in length 1.3 mm. (range 1.3–1.4 mm.) and in height .80 mm.; ventral valves turn dorsally and are wide and stout for horizontal length, averaging .22 mm.; angle formed by horizontal and tangent lines—32 degrees; whole structure appears weak and widely spread from a dorsal view. Legs with the coxae black; rest of legs with a basic color of yellowish brown; black infuscation appears as a spot, medially, on outer face of hind-femurs and occasionally on hind-tibiae; no black on fore and mid-legs; tarsi white. Thorax with the tegulae brown. Propodeum with a narrow median depression divided by a central ridge for whole length; small lateral ridges extend from central ridge across depression to ridges bounding depression; at top of median depression are two large, shiny concavities, above these a narrow crescentic pit; below median depression is a deep, very distinct rectangular pit; median depression slightly wider at top than at bottom. Eyes, from a view of the head from above, are slightly bulgy behind. Antennae with the anterior face of the scape yellow on lower half only; rest black; pedicle small and round and may be dark brown to black. Wings average in length 2.6 mm. (range 2.5–2.7 mm.); veins lemon yellow; postmarginal averages .21 mm. (range .20–.25 mm.) in length and the marginal .35 mm. (range .30–.42 mm.); thus the postmarginal is more than half as long as the marginal; stigmal club quite deeply rounded basally which causes it to appear almost square. Wing-body ratio of 1.11.

*Male*.—Length ranges from 2.5 to 3.3 mm.; average 2.9 mm. Wing veins dark brown in color; more black on hind-femurs than in females.

*Types*.—29 females and 23 males; holotype female and allotype male along with paratypes of both sexes in the Bugbee collection, Hays, Kansas.

*Type Locality*.—Labels read, San Buenaventura, 3 miles east, State of Chihuahua, Mexico; 5600 feet altitude; galls collected on October 16, 1931; males and females emerged in the spring of 1932.

*Host*.—Labels read, from galls of an undescribed species of the *Disholcaspis globulus* complex, Kinsey det., on *Quercus chihuahuensis*, Kinsey coll.

*Range*.—Known only from the type locality, but it very likely ranges north and south of San Buenaventura along the mountain range.

This species stands out as quite distinct from any of the others so far described. The more globular, plumper abdomen, differently shaped genitalia, and longer postmarginal vein in relation to the marginal will differentiate it from the others. Just what its relationships are cannot be stated at this time. Very likely it belongs to a distinct complex from any of the others but the exact nature of its position within the *Breviura* group will have to wait until more material is available from Mexico.

***Eurytoma excellens*, n. sp.**

(Plate I, figs. 4 and 9)

*Female*.—Length, 2.6 to 3.7 mm.; average 3.1 mm. Abdomen conic ovate in outline from the side; considerable lateral compression; a few short white hairs on lateral aspect of segment 6; width of abdomen from above .70 mm. (range .65–.85 mm.); depth from the side 1 mm. (range 1–1.2 mm.); scaling on lower lateral aspect of segment 6 covers about half of surface; exposed tip of dorsal valves longer and more pointed, averaging about .20 mm. (range .17–.26 mm.) in length than in other species of this group; exposed tip of dorsal valves and of ovipositor sheaths stick upward at an angle of 45 degrees or more in relation to horizontal axis of abdomen; segment 6 about equal in width at widest point to width of segments 4 and 5 combined at their widest point; front part of abdomen with considerable dorsal extension. Genitalia averages in length 1.6 mm. and in height 1.3 mm.; dorsal valves narrow for horizontal length (averaging .15 mm.) and at anterior end turn dorsally and slightly posteriorly; ventral valves turn dorsally also and then bend posteriorly on themselves; angle formed by horizontal and tangent lines—54 degrees; stylet arch in a vertical plane. Legs with the coxae black; basic color of legs reddish brown; black infuscation may be present on fore and hind-femurs and all tibiae; never seems to be present on mid-femurs; tarsi white. Tegulae reddish brown. Propodeum with a short and broad median depression; central ridge runs down middle of depression from which emanate 4 to 5 distinct lateral ridges that connect with sharply defined ridges that outline median depression; whole depression wider at top than at bottom and wider than any other species of this group; at top of depression is a rectangular pit and at bottom a very shallow one. Antennae filiform with the basal half of the scape yellow; rest black. Wings average in length 2.6 mm. (range 2.4–2.8 mm.); veins reddish yellow to deep brown; marginal vein averages .33 mm. (range .27–.45 mm.) and the postmarginal .21 mm. (range .17–.27 mm.) in length; thus the postmarginal

is more than half the length of the marginal; stigmal club rectangular and gently rounded basally. Wing-body ratio of 1.20.

*Male*.—Length varies from 2.1 to 3.0 mm.; average 2.6 mm. Too poor for further description.

*Types*.—14 females and 3 males; holotype female and allotype male along with paratypes of both sexes in the Bugbee collection, Hays, Kansas.

*Type Locality*.—Labels read, Aquascalientes, 35 miles east, State of Jalisco, Mexico; elevation 7000 feet; galls collected on November 28, 1931; males and females emerged in the spring of 1932.

*Host*.—Labels read, from galls of an undescribed species of the *Disholcaspis jungiformis* complex, Kinsey det., on *Quercus undata* Kinsey coll.

*Range*.—Known only from the vicinity of the type locality.

This species, like the preceding one, is different enough from any of the others to suggest that it probably represents a distinct complex of its own. It may be separated from the other species by its differently shaped abdomen, genitalia, depression on the propodeum, and the relation of the length of the marginal and postmarginal veins.

## AUREATA GROUP

### PART IV

(Map No. 2 and Text figures 10 and 11)

The Aureata group includes *E. tepicensis* Ashmead (1895) and two new species described below.

Species of the Aureata group may be told from those of the Breviura, Mucronura and Atrateges groups by the plumper abdomen; very short, stubby, exposed tip of the dorsal valves; and almost total absence of black infuscation on the legs which are all yellow or brown including fore and mid-coxae. The different host relationships can also be used.

The Aureata group appears to be closest in its structural characteristics to the Breviura group. This is suggested by similar sculpturing of the propodeum; relationship of the length of the marginal and postmarginal veins of the fore-wing, and the general proportions of the genitalia.

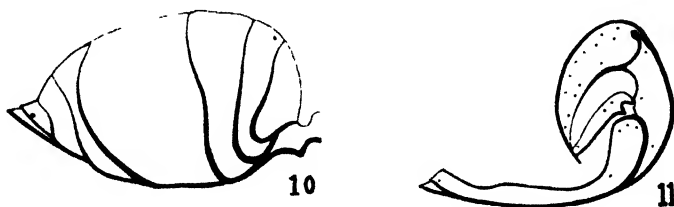
The species of this group, when all their host relationships are known, will probably be found to be restricted to the host genus, *Andricus* (*Cynipidae*).

### *Eurytoma aureata*, n. sp.

(Map No. 2).

*Female*.—Length ranges from 2.7 to 3.9 mm.; average 3.3 mm. Abdomen circular in outline from the side; plump; depth averages 1 mm. (range .95–1.2 mm.) and width from above .75 mm. (range .60–.85 mm.); exposed tips of the dorsal valves very short and stubby and they barely project beyond the end of the abdomen; average about .09 mm. or less (range .07–.10 mm.) in length; fine scaling

on lateral aspect of segment 6 covers about two-thirds to three-fourths of surface; plays out dorsally. Genitalia averages 1.3 mm. (range 1.1–1.5 mm.) in length and 1.0 mm. (range .85–1.1 mm.) in height; dorsal valves thin for horizontal length (average .11 mm.; range .07–.15 mm.) and turn dorsally, anteriorly; ventral valves turn dorsally also but not backwards; angle formed by tangent and horizontal lines—45 degrees; stylet arch approaches close to a vertical plane. Legs with the front-coxae yellow along inner margins and in a few with a yellow tinge to the mid-coxae; basic color of femurs and tibiae yellow to reddish-brown; slight black infuscation, when present at all, on hind-femurs only; tarsi white. Tegulae brown. Propodeum with a shallow median depression, wider at top than at bottom; divided by a fine central ridge that plays out basally; below base of median depression is a shallow rectangular pit that often appears divided by a median ridge; arcus lateral to median depression shagreened. Eyes, from above, bulge laterally; no noticeable round pit below eye. Antennae clavate with the outer face of scape yellow in most; pedicel dark brown in some specimens; rest black; club,



TEXT FIGURES 10 AND 11

Genitalia and Abdomen of a New Species of the genus *Eurytoma* from Mexico (Aureata Group):

FIG. 10 Female abdomen of *Eurytoma numerosa*. 11. Female genitalia of *Eurytoma numerosa*.

especially tip, may be dark brown in some. Wings with the veins straw yellow; not heavy; marginal vein averages .36 mm. and the postmarginal vein .18 mm. in length; stigmal club rectangular and gently rounded basally. Wing-body ratio of 1.22.

*Male*.—Length, 2.7 to 4.2 mm.; average 3.5 mm. Legs with both fore and mid-coxae yellow; hind-coxae black; rest of legs all yellow to yellowish-brown; slight black infuscation appears medially on hind-femurs in only a few; wing veins heavy and yellowish-brown; gold tinge to pile covering face and thorax. Outer face of scape yellow for whole length.

*Types*.—53 females and 20 males; holotype female and allotype male along with paratypes of both sexes in the Bugbee collection, Hays, Kansas.

*Type Locality*.—Labels read, Rio Verde, 14 miles west, State of San Luis Potosí, Mexico; elevation 6000 feet; galls collected on December 4, 1931; males and females emerged in the spring of 1932.

*Host*.—Labels read, from galls of an undescribed species of the *Andricus aciculatus* complex, Kinsey det., on *Quercus polymorpha*, Kinsey coll.

*Range*.—Known only from the type locality but probably covering the mountain ranges in the vicinity of Rio Verde.

This species and the next one are very closely related. Upon a superficial acquaintance they are very hard to separate, but on careful study they may be differentiated on the basis of the following characteristics: *E. aureata* averages slightly larger than *E. numerosa* and this is carried over into the relation of the length of the marginal and postmarginal veins; in *E. aureata* both veins average longer than in *E. numerosa*; the stigmal club in this species is gently rounded basally while in *E. numerosa* it is flat or triangular basally; *E. aureata* has more yellow on the front and mid-coxae of both males and females, as well as on the scape of the antennae. The different host relationships and distribution will also aid in separating them.

***Eurytoma numerosa*, n. sp.**

(Map No. 2; Text figures 10 and 11)

*Female*.—Length, 2.5 to 3.5 mm.; average 3.1 mm. Abdomen circular in outline, plump; width is equal to .75 mm. (range .70–.85 mm.) from above and depth, from the side, 1. mm. (range 1.–1.2 mm.); exposed posterior tips of the dorsal valves very short and stubby, averaging about .07 mm. in length; lateral surface of segment 6 finely scaled; covers about one-half to two-thirds of surface. Genitalia averages 1.1 mm. (range 1–1.2 mm.) in height and 1.4 mm. (range 1.2–1.5 mm.) in length; dorsal valves thin for horizontal length (average .10 mm.; range .07–.12 mm.); turn dorsally anteriorly at right angles; ventral valves turn dorsally also and very slightly posteriorly; angle formed by tangent and horizontal lines—50 degrees; stylet arch in a vertical plane or very nearly so. Legs with tinge of yellow toward median edge of fore-coxae; rest of coxae black; reddish-brown femurs in most cases with no black infuscation medially; in a few black may appear on hind and mid-femurs; tibiae usually all reddish-brown with tips lemon yellow; slight black infuscation on mid-tibiae of a very few. Tegulae brown. Propodeum with a shallow median depression which is wider at the top than bottom; central ridge divides depression into two halves for about half its length in most; in a few may continue to base of depression; at base of depression is a rectangular pit; small lateral ridges cross from median ridge to boundaries of depression dividing areas up into small squares or rectangles; lateral to median depression, areas finely shagreened. Eyes, from above, bulgy laterally; fine, round, shallow pit below eye. Scape of antennae all yellow. Wings with the veins reddish-brown; marginal vein averages .33 mm. and postmarginal .15 mm. in length; stigmal club either rectangular or bottom deeply triangular in outline. Wing-body ratio of 1.24.

*Male*.—Length ranges from 2.2 to 3.5 mm.; average 2.9 mm. Legs with the front-coxae all yellow; mid-coxae may be all yellow or show only a tinge of yellow; black or dark brown infuscation may

appear on hind-femurs and tibiae and mid-tibiae in majority; a few show all yellow legs. Scape with upper one-fourth to one-half black on outer face; rest yellow in majority.

*Types*.—33 females and 16 males; holotype female and allotype male along with paratypes of both sexes in the Bugbee collection, Hays, Kansas.

*Type Locality*.—Labels read, C. Victoria, 21 miles west, State of Tamaulipas, Mexico; elevation 3200 feet; galls collected on January 21, 1932; males and females emerged in the spring of 1932.

*Host*.—Labels read, from galls of an undescribed species related to *Andricus furnessae* Weld, Kinsey det., on *Quercus polymorpha*, Kinsey coll.

*Range*.—Probably extending over a considerable area of the mountain ranges north, south and west of C. Victoria.

*E. numerosa* is closely related to the preceding species (*E. aureata*). Their differences and similarities are pointed out under the description of *E. aureata*.

### ***Eurytoma tepicensis* Ashmead**

*E. tepicensis* Ashmead. Proc. Calif. Acad. Sci. 5: 551, 1895.

*E. tepicensis* Bugbee. Jour. Kans. Ent. Soc. 14(2): 56, 1941.

The following description of *E. tepicensis* is that of Ashmead: Length 2.2 mm.; black; scape and legs, except coxae and the hind femora medially brownish-yellow; tegulae black; wings hyaline, the veins brownish-yellow.

*Head and Thorax*: Flagellum, legs and apex of abdomen, clothed with a sparse, glittering, white pubescence. The flagellum is not quite three times as long as the scape, the pedicel is half as long as the first joint of funicle, very little longer than thick at apex; funicle 5-jointed, without counting the single ring-joint; the first joint being the longest, or fully twice as long as thick, the following very slightly decreasing in length so that the fifth joint is only slightly longer than thick; club 3-jointed, a little shorter than the scape. The pronotum seen from above is almost as long as the mesonotum, the scutellum to its tip being considerably longer than the mesonotum; metanotum medially, sulcate, the sulcus having two delicate parallel carinae, the space between them being filled with delicate transverse raised lines. Marginal vein of front wings rather stout, one and one-half times as long as the stigmal, the latter being a little shorter than the postmarginal.

*Abdomen* subsessile, not longer than the thorax, blunt at the apex, the 5th segment the largest, about two and one-half times as long as the 4th, the 6th about half the length of the 4th, the 7th a little longer than the 6th, bearded with white hairs and bearing spiracles, the 8th segment retracted.

*Type*.—Described from one female specimen located in the collection of the California Academy of Sciences, San Francisco, California.

*Type Locality*.—Tepic, Mexico, State of Nayarit.

*Host*.—Unknown.

Mr. C. D. Michener of the University of California, who compared specimens representing the *Atrateges* group with the single female type of *E. tepicensis*, described Ashmead's species by letter as follows:

"Abdomen, areas on sides of thorax, and coxae dark brown; tegulae shining brown; apex of abdomen not nearly so produced as in your specimens (*refers to specimens belonging to Atrateges group*); abdomen impunctate, strongly shining, and much less compressed than in *Atrateges*; trochanters, femora, tibiae, and tarsi yellow, posterior femora brown medially (no black infuscation); wing veins whitish, vein 'a' (*postmarginal*) noticeably shorter than 'b' (*marginal*)."  
*Italics mine.*

It is obvious, from a comparison of the two descriptions, that they do not jibe at several points. Ashmead described the tegulae as "black" while Michener describes them as "shining brown"; Ashmead implies that the coxae are not yellow, but black, while Michener describes them as "dark brown," etc. This apparent disagreement appears to be another case in which Ashmead may have described a species as *E. tepicensis* from one specimen and attached the label of some other specimen. Or he may have used two different insects for one description as Michener believes he did in a case among the bees. Quoting from a letter from Michener, he says, "In one case, he (Ashmead) almost certainly described the head and thorax of one bee, then went out and upon returning picked up another species for the description of the abdomen."

More recently Dr. E. Gorton Linsley compared specimens of *E. aureata* and *E. numerosa* with the type of *E. tepicensis* and in a letter states, "I would say that in general this species (*E. tepicensis*) agrees pretty well with your description of the *Aureata* Group."

Thus *E. tepicensis* differs from *E. aureata* and *E. numerosa* in the presence of "dark brown" color on the abdomen and sides of the thorax and the "impunctate" sides of the abdomen. It agrees with the species of the *Aureata* Group as follows: The short, stubby ends of the dorsal valves; dark brown to yellow-brown tegulae and coxae; yellow legs; lack of black infuscation on femurs and tibiae and the relation of the length of the marginal and post-marginal veins.

Until more material from the same locality can be studied, *E. tepicensis* is placed in the *Aureata* Group, where it would seem to fit into a complex of its own (*Tepicensis* complex as distinct from the *Aureata* complex).

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# THE NESTING HABITS OF THE WASP, CHLORION (AMMOBIA) PENNSYLVANICUM L.<sup>1</sup>

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This wasp, the "Great Black Wasp" of John Bartram, is of historic interest, for it was the first solitary digger wasp to be described from this country; an account of the behavior of the Great Black Wasp from Pennsylvania was communicated by Mr. John Bartram to Mr. Peter Collinson and read before the Royal Society on December 21, 1749.<sup>2</sup>

Despite the implications of its name, this wasp is found to be fairly abundant in the Missouri valley. Here, for a number of years, I have found them on flowers, but I had never seen them in the act of nest-making until I was led by an observing friend to see a colony in 1938.

With amazement, I viewed a large aggregation of these wasps nesting in the ground at the home of Mr. Shepherd at Pacific, Missouri. These activities were not being carried on in the open sunshine, as is the custom of sister species, but in the subdued light of an abandoned tool-house, where they came and went through the broken window panes as they dug their burrows in the soft dirt floor. It seems to be the habit of these wasps to nest in sheltered places, for Rheinhardt also found them nesting in a similar shelter.

In the earthen floor of this tool-house, on September 4, were twenty open burrows, each with its mound of excavated dirt beside it, and each with a mother wasp either carrying out more dirt or bringing in prey as provender for her young. This dirt floor, seldom trodden upon by man, was soft, and afforded easy digging for the wasps. The uniformly soft soil here, without debris or stones, made excavating an easy task for them.

In digging, the mothers would bite out the soil, load it on the partly outstretched front legs, hold it in place with their jaws, walk out of the burrow backwards and drop the load on a neat pile at one side of the hole. When the pile had become too high, and there was danger of the dirt falling back into the burrow, she would scatter the subsequent loads to the winds by very rapid brushing movements of the front legs. The nests were so close to one another that it often happened that a busy mother would break through the thin wall into a completed nest, and presently bring up and throw away a good cocoon containing a neighbor's offspring.

One nest which I excavated measured an inch in diameter at the opening, went down diagonally at an angle of 45 degrees for five inches, then turned backwards and continued horizontally for two inches, and finally terminated in a pocket one and one-half inches long by one-quarter inch in height. This pocket contained five adult katydids, all of the species *Phaneroptera furcata* Brunner [A. B. Gurney], one

<sup>1</sup>Species identified by the late Grace A. Sandhouse.

<sup>2</sup>E. G. Rheinhardt, *The Witchery of Wasps*, pp. 165-176, 1929.



of which bore an egg on the under side of the abdomen.<sup>3</sup> The katydids showed only the faintest trace of life, and that only when stimulated. Even though the prey was as large as the wasp, the latter had no difficulty in transporting them through the air, flying gracefully and swiftly through the open window and placing the prey at the opening of the nest; there they left them for a few seconds while they made a final inspection of the burrow, and finally emerged as far as the threshold and pulled the prey into the hole.

The season for the adult life of this species is evidently long, for they were at work in early September, and a cocoon which I excavated at that time gave forth an adult male on June 19, 1939. The indications are, therefore, that the length of life of the adult is a little more than three months. It seems probable that the males are shorter lived, because none were seen in the busy colony the first week of September.

The consensus of reports indicates that this species requires for its nesting purposes soft earth and adequate shelter, for Reinhardt likewise found a large colony of them in the same kind of situation, the soft earth in an unused greenhouse, where they had access through broken windows and open door. Bequaert also found a sister species, *Chlorion* (*Ammobia*) *caliginosum*, in Colombia,<sup>4</sup> also a hunter of longhorned grasshoppers, likewise excavating nests in the floor of an abandoned building, this time an old church, and coming and going through the open windows. They seem to feel an urge to seek overhead protection, for several of those in the tool-house had chosen nesting-sites under overturned tubs or boxes. I wonder if this species ever nests in the open fields, as do other species of the genus *Chlorion*. Possibly an answer to this question lies in the aforesaid observation, for if they seek sheltered places in the fields as they do here, they would seldom be found.

<sup>3</sup>Reinhardt observed the species stocking the nests with *Microcentrum laurifolium* and *Scudderia furcata*.

<sup>4</sup>Bull Brooklyn Ent Society, 32: 186, 1937.

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THE BIOTIC PROVINCES OF NORTH AMERICA, by LEE R. DICE. viii+78 pp., 1 map. University of Michigan Press, Ann Arbor, Michigan, 1943. Price \$1.75.

When a book so arouses my interest within a few pages that I want to read the rest, I regard it as a good book. This one has done more. Its logical evaluation of data has not only aroused interest but has also left a feeling of confidence in the practical value of its biotic provinces for other fields of biology. And after reading I was not contented until I had subjected some of my taxonomic problems to the test of Dice's biogeographical findings. The results were several: They confirmed the author's emphasis on plant life as the chief basis of the provinces, stated on page 5, and the continuing statement on page 6 concerning the imperfect correlation between plant and animal distribution at the boundaries of the provinces. Nevertheless the bearing of his findings on the difficult taxonomic distinction involved was so helpful that it implies high value for this work as an adjunct of taxonomy and strongly suggests that it must be an important contribution in its own special field.—A. W. L.

# ILEAL CAECA IN THE EUMASTACIDAE (ORTHOPTERA)

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In one of several papers on the internal genitalia of female Orthoptera it was noted that those species which belonged to the family Eumastacidae each had six well-developed, fingerlike diverticula or caeca attached to the hindgut not far from its anterior end (Slifer, 1943). Approximately 340 species of Orthoptera, distributed through four related families (Tetrigidae, Eumastacidae, Proscopiidae and Acrididae), were examined in this series of studies on the genitalia and since caeca were found on the hindgut in none except members of the Eumastacidae their presence in this one group would seem to deserve closer attention.

The number of species on which this report is based is small, but since the individuals were collected in widely-separated localities (Africa, Java, North America and South America) it is not unlikely that the results secured with them will be found to apply to other Eumastacidae as well.

## MATERIALS AND METHODS

The following members of the Eumastacidae were examined:

*Erianthus guttatus* Westwood.

*Erucius* sp.

*Eumastax surinama* Burr.

*Gymnotettix lithocolletus* Rehn and Rehn.

*Malagassa* sp.

The first and last three species listed above were available only as dried, pinned museum specimens. The abdomen of each of these was treated with a hot solution of potassium hydroxide and then dissected. Since the ileal caeca are lined with a chitinous intima—as is the rest of the hindgut—they can be identified readily in such preparations even though all of the cellular parts have been destroyed.

About a dozen preserved specimens of *Erucius* sp. were sent to the writer by Dr. E. R. Helwig. These consisted of adults and last instar nymphs which had been carefully fixed so that the internal organs were in excellent condition for histological study as well as for dissection. Both cross and longitudinal sections of the alimentary canal were made and stained either with Heidenhain's hematoxylin or with Mallory's triple connective tissue stain. The latter proved especially helpful in bringing out more clearly the basement membrane and the limits of the chitinous lining of the hindgut.

<sup>1</sup>The author wishes to thank Dr. B. P. Uvarov, of the British Museum, Mr. J. A. G. Rehn, of the Academy of Natural Science in Philadelphia, and Dr. E. R. Helwig, of the University of Pennsylvania, for generously contributing the material for this study. Dr. T. N. Tahmisian of this department made the photomicrograph shown in figure 2.

*Alimentary canal.*—The alimentary canal of *Erucius* sp. is in no way unusual except for the presence of caeca on the hindgut. The foregut needs no special mention and, as may be seen in figure 1, the midgut is provided with six gastric caeca which are not markedly different from those found in the Acrididae. The hindgut is divided into three distinct regions—ileum, colon and rectum—and of these only the first will be discussed here.

*The ileal caeca.*—Twelve groups of Malpighian tubules enter the anterior end of the ileum. Six of these groups contain about 14 or 15 tubules each and the remaining six only one or two tubules each. The large and small groups are arranged alternately around the ileum. The total number of tubules, then, is not far from one hundred. The tubules of each group enter a small sac or ampulla which, in turn, opens into the hindgut (AMT, figs. 1, 7). From the posterior region of each of the ampullae which are associated with the large groups of tubules—but not from the small ones—an excretory furrow (EF, figs. 4, 5, 7) passes



FIGURE 1. Alimentary canal of adult female *Erucius* sp., Malpighian tubules omitted, except for ampullae. AMT, ampullae of Malpighian tubules; C, colon; FG, foregut; GC, gastric caeca; I, ileum; IC, ileal caeca; MG, midgut; R, rectum.  $\times 8$ .

back along the lining of the ileum. Posteriorly each of these six excretory furrows turns forward into one of the ileal caeca and ends close to its anterior tip. These furrows are open for their full length to the lumen of the ileum and to the cavities of the ileal caeca as well but their structure is such that when the walls of the ileum are constricted by the extremely heavy muscular layers on their outer surface (CM, LM, M, figs. 4, 7) these furrows must, for all practical purposes, serve as closed canals. In the caeca, however, they would probably remain open for the muscular layers here are poorly developed. Posteriorly the caeca open directly into the ileum.

*Histological structure.*—Histologically the most conspicuous feature of the ileal caeca is the single layer of large epithelial cells (E, fig. 3). These are provided along their outer border with a delicate basement membrane (BM) and their inner edges are covered with a rather thin chitinous cuticle or intima (C). Just beneath the cuticle the cytoplasm of the epithelial cells shows a well-developed striated border (SB) suggestive of that commonly found in the epithelial cells of the midgut and Malpighian tubules of insects. Externally each caecum is supplied with a half dozen or so widely-separated, narrow, longitudinal muscles (LM). These meet near the tip of the caecum. Running at right

angles to these muscles, and between them and the basement membrane, are inconspicuous, scattered groups of circular muscles (CM). A comparison of the walls of the caeca with that of the ileum itself brings out several differences: *first*, the chitinous intima in the caeca is much thinner than it is in the ileum; *second*, the epithelial cells in the caeca are larger than are those in the ileum; and *third*, the muscular layers of the caeca are much less conspicuous than are those of the anterior part of the ileum. The muscles of the caeca more nearly resemble those of the posterior part of the ileum.



FIGURE 2. Cross section through alimentary canal of adult female *Erucius* sp. in region of ileal caeca.  $\times 90$ .

*Function of ileal caeca.*—The ileal caeca in some specimens of *Erucius* sp. were either empty or else contained traces of a fine granular coagulum; in others the caecal cavities were filled or partially filled with a compact brown mass (BM, fig. 4). In sections this appeared as an amorphous material, occasionally vacuolate, composed of blobs and granules of variable size. Little could be determined concerning the nature of this material except that it is, after fixation, not dissolved by the various agents used in making paraffin sections. In preparations treated with Mallory's connective tissue stain it is a greenish-blue.

In some animals a brown substance similar to that in the caeca was found also in the ileum posterior to the caecal openings and outside the peritrophic membrane, which envelops the food residue in the intestine. This, of course, is to be expected for the posterior ends of the caeca open widely to the ileum (O, figs. 6, 7). It may be assumed, then, that the contents of the caeca are passed into the ileum.

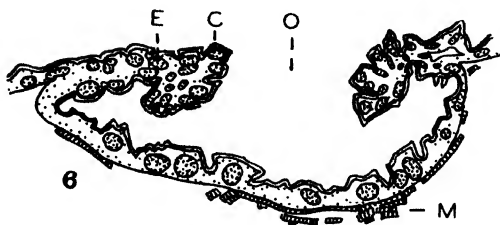
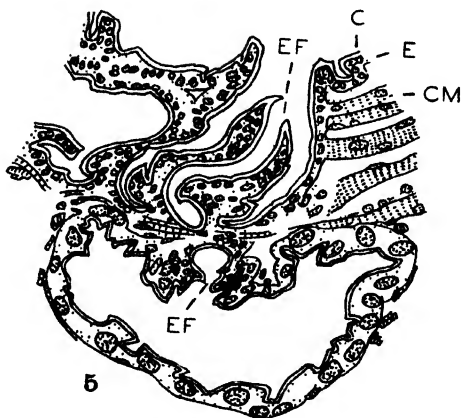
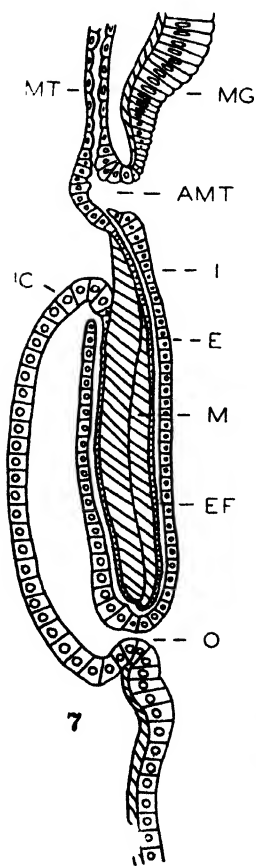
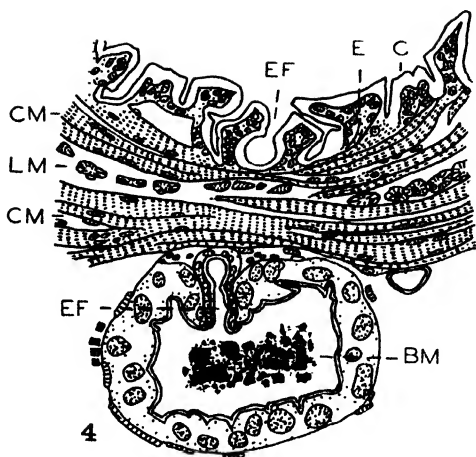
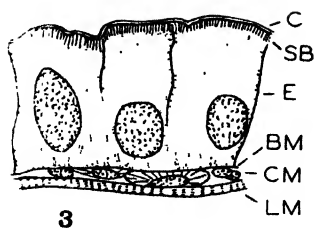
The source of the caecal contents is more difficult to determine. Traces of a brown material similar to that described above were found in the excretory furrows both in the caeca and in the ileum and, in one case, a little of it was seen in the ampullae of the Malpighian tubules. The evidence here is by no means conclusive but it does suggest that material from the Malpighian tubules is passed by way of the excretory furrows into the ileal caeca, accumulates there, and, eventually, reaches the posterior portion of the ileum.

On the other hand it is conceivable that the material found in the caeca may originate there for the epithelium consists of very large cells quite similar to those in other orthopteran organs which are known to be secretory in nature. However, insect epithelial cells which produce secretions and which, at the same time, are covered with a cuticle through which these secretions must pass, are commonly provided with minute, chitinous canaliculi. These, at one extremity, penetrate deep into the epithelial cells and, at the other, open through the cuticle into the lumen of the secreting organ. No such canaliculi were found in the eumastacid ileal caeca and their absence would argue against a secretory function for these parts.

The structure as well as the relationships of Malpighian tubules, excretory furrows and ileal caeca, then, all suggest strongly that materials originating in the tubules pass into the caeca by way of the excretory furrows and from there later reach the ileum. In the diagram (fig. 7) the ampulla of the Malpighian tubules is shown as if it

#### EXPLANATION OF FIGURES 3 TO 7

Fig. 3. Longitudinal section through portion of wall of ileal caecum of last nymphal instar of *Erucius* sp. BM, basement membrane; C, cuticle; CM, circular muscle; E, epithelium; LM, longitudinal muscle; SB, striated border.  $\times 365$ . FIG. 4. Cross section through an ileal caecum and adjacent wall of ileum of adult *Erucius* sp. Section passes close to anterior tip of caecum. BM, brown material found in lumen of caecum; C, cuticle; CM, circular muscle; E, epithelium; EF, excretory furrow; LM, longitudinal muscle.  $\times 150$ . FIG. 5. Cross section through wall of caecum and adjacent wall of ileum. Same specimen as fig. 4. Section close to region where excretory furrow turns forward into caecum. C, cuticle; CM, circular muscle; E, epithelium; EF, excretory furrow.  $\times 150$ . FIG. 6. Cross section through wall of ileal caecum and adjacent wall of ileum. Same specimen as fig. 4. Section close to posterior end of caecum. C, cuticle; E, epithelium; M, muscle; O, opening of caecum into ileum.  $\times 150$ . FIG. 7. Diagram of longitudinal section through part of wall of alimentary canal of last instar nymph of *Erucius* sp. One side only of alimentary canal shown. No attempt has been made to represent the narrow longitudinal opening which extends the entire length of the excretory furrow and by means of which it communicates with the cavity of the ileum and of the ileal caecum. AMT, ampulla of Malpighian tubules; E, epithelium; EF, excretory furrow; I, ileum; IC, ileal caecum; M, muscle; MG, midgut; MT, Malpighian tubule; O, opening of caecum into ileum.  $\times 70$ .



were open to the intestine. In effect, however, this is not the case for portions of the ileal lining protrude anteriorly between the ampullae and then extend laterally in such a way as to block, more or less completely, the opening to the hindgut. Thus we might expect to find that that greater part of the products of the tubules drains into the ileal caeca but that some of it escapes into the anterior part of the ileum. In this connection it should be noted again that the six small groups of Malpighian tubules, which alternate with the large groups, have no excretory furrows of their own and, likewise, no ileal caeca. Presumably their secretions also go directly into the intestine.

It is impossible at this stage of our knowledge to draw any definite conclusions regarding the function of the ileal caeca. Perhaps they are a device for the conservation of water or some other substance lost through the Malpighian tubules. The extreme thinness of the cuticular lining of the caeca hints that this might be the case. But, until someone is able to examine the caeca in the living condition the problem will, most likely, remain unsolved.

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## THE ANTS OF THE CHICAGO REGION<sup>1</sup>

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The area at the southern end of Lake Michigan is interesting ecologically for the transition between the deciduous forests and the "prairie wedge;" the latter reaches its most eastern extension in Indiana. There is also a well-marked transition between the boreal and the austral portions of the forested land, and semi-arid conditions prevail in the dune localities.

Numerous papers on the geological and ecological features of the region have been published (Salisbury and Alden, 1899; Fryxell, 1927; Cowles, 1899, 1901; Shelford, 1907, 1908, 1911, 1912, 1913; Fuller, 1914, 1925, 1934, 1935; Pepon, 1927; Peattie, 1930; O. Park, 1930, 1931 a, b, 1935, 1937; Park, Lockett and Myers, 1931; Park and Keller, 1932, Park and Sejba, 1935; Park and Strohecker, 1936; Pearson, 1933; Talbot, 1934; Strohecker, 1937 a, b, 1938; Lowrie, 1942). In addition, studies on the biology of a local aggregation of *Formica ulkei* nests have been contributed (Holmquist, 1928; O. Park, 1929; T. Park, 1929; Dreyer and Park, 1932).

The materials for this report were accumulated while the author was engaged on another program, and are largely qualitative as no exact sampling methods were employed. Yet, to one collecting a specific group in a limited area the degrees of abundance soon become evident, and from such experience an indication of the relative numbers of each species is included in the table of habitat comparisons (Table I; see also Table III). The number of places actually visited is not large, but selected localities representing sixteen major habitats have been investigated repeatedly.<sup>2</sup>

<sup>1</sup>The excellent study by Dr. Mary Talbot on adaptive differences among certain *Formicae* and the ecological distribution of ant species in the vicinity of Chicago, Illinois, has led the author to undertake similar field studies and to record the results with the view of adding new data for the region. It is hoped this report will be of aid to those wishing identification of the local ants.

<sup>2</sup>I wish to acknowledge indebtedness to the following persons whose help has been greatly appreciated. Dr. Talbot afforded much early assistance with the taxonomy of ants and the checking of determinations. Dr. Neal A. Weber has graciously supplied the names for certain species of *Myrmica*. Dr. Donald C. Lowrie, and others whose names appear in connection with the localities collected, have added many specimens. My sincere thanks are extended to the Department of Zoology for providing various facilities, and to my wife, Ella Virginia Gregg, I am especially grateful for aid in numerous instances and for many specimens. To Mr. R. W. Miller belongs the credit for preparation of the photographs.



## THE CHICAGO REGION

Prairies lie west and southwest of Chicago, and ant mounds are everywhere visible although the number of species is low. Eight species are listed but only *Formica cinerea neocinerea* is abundant, and probably ninety-five per cent of the nests are constructed by this form. *Polygerus rufescens breviceps*, one of the rarest of ants, is present locally as a parasitic (dulotic) species on this vast assemblage of *cinerea* nests.

At the junction of prairie and forest a rich parkland and savanna is found, and this is shown by the interdigitation of grasslands on the upland with trees along the watercourses. Forest margin and meadow are important habitats and such ants as the yellow *Lasius*, *Formica ulkei* and *Formica sanguinea* can be expected to occur. It may be surmised that the total amount of forest-prairie ecotone is larger than formerly, and correlated with this may be an increase in the number of ant species. Certain inhabitants of the deep woods may be rarer than when climax forests were continuous. The ant, *Proceratium silaceum*, is probably an illustration of this tendency (Kennedy and Talbot, 1939).

On the terminal and ground moraines and outwash deposits to be seen at Palos Park, Orland Park, New Lenox, Volo, Aurora, Illinois, and Lake Geneva, Wisconsin, there are stands of oak forest. Black, red and white oaks are mixed in varying proportions, and the ants *Prenolepis imparis*, *Formica fusca subaenescens*, *F. f. subsericea* and *Lasius niger alienus americanus* are common members of the community. Along streams and ravines elm and hickory are added indicating more mesic conditions (e.g., at New Lenox, Mount Forest Island at Palos and at Hadley, Illinois), and the ant *Camponotus herculeanus pennsylvanicus ferrugineus* often makes its appearance in these situations.

The oak-hickory forest is perhaps the physiographic climax for some localities, but beech seems to be restricted to the more humid stations in northern Indiana and southern Michigan. This lake-border region marks a portion of the western boundary of the beech-maple-hemlock cover type, and stands of this climax were studied at Warren Woods (Lakeside), Michigan, and at Smith, Indiana, both on mixtures of silt and clay. The ants most strikingly associated with the beech-maple forest are the several species of the *Aphaenogaster fulva* complex, *Myrmecina graminicola americana* and *Leptothorax longispinosus*.

Floodplain forests on argillaceous substrata flank the numerous rivers, and collections were made in the Salt Creek Forest Preserve of Chicago (elm and oaks), and beside Coffee Creek near Chesterton, Indiana (elm-oak-maple-basswood). The ants of this community do not differ radically from those of the oak and oak-hickory types, but the single nest of *Strumigenys pergandei* was collected from a log in the Coffee Creek woods.

The area about the head of Lake Michigan originally was one of extensive marshes, but unfortunately, much of this land has been drained. In the marshes of the Palos hills, the temporary marshes of the low prairie southwest of Chicago and in the Lake Calumet district, the prairie ant, *Formica c. neocinerea*, is the most obvious resident.

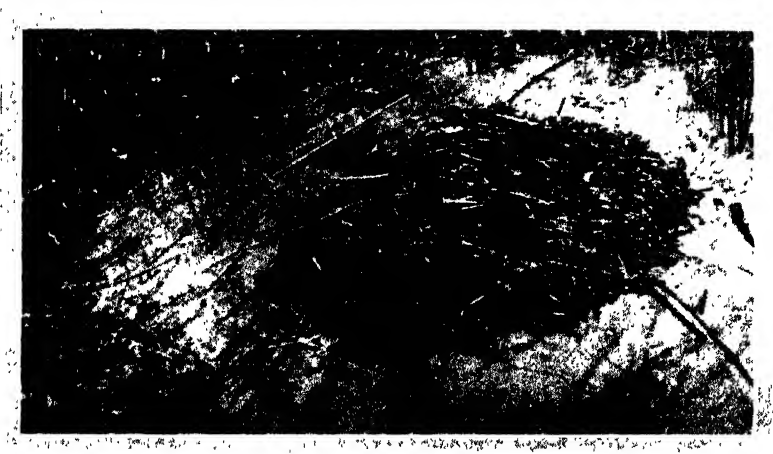


FIG. 1. Low, thatch covered mound of *Formica rufa aggerans* Wheeler in the dunes at Waukegan, Illinois. Photo by Zora Ivaska.

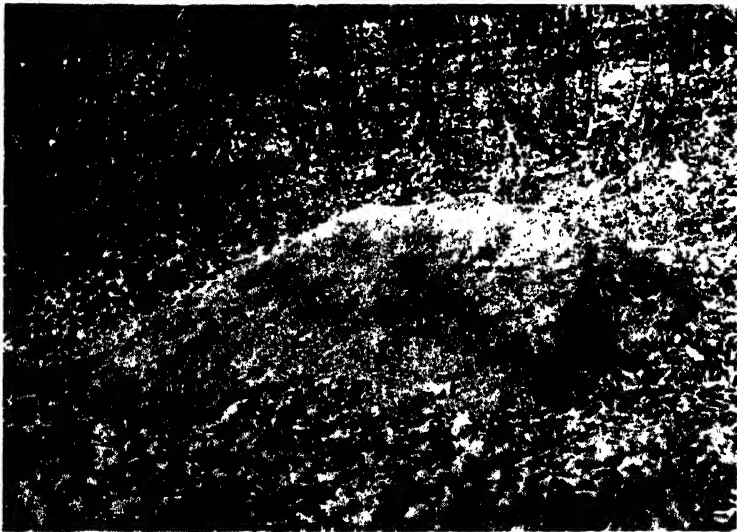


FIG. 2. Masonry dome of *Formica ulkei* Emery from the local aggregation of these ants at Palos Park, Illinois. Shows differential angles of slope oriented with reference to the sun; longest slope faces south. Photo by A. S. Windsor.

This may be due to its capacity for building high conical domes which could stand above the water during periodic inundation, but the author did not succeed in proving this supposition. In drier prairies, however, the mounds were much lower. In the senescent marshes of the Gary Pond Series at Hammond, Indiana, were found several nests of *Formica ulkei*, and even more astonishing were a number of large formicaries of *Lasius umbratus mixtus aphidicola* (see discussion of this species below).

Bogs are infrequent but one mid-stage tamarack bog in the lake region near Volo, Illinois, was visited several times and a senescent bog at Dune Acres, Indiana, on at least one occasion. The ant fauna of bogs is, as far as observed, rather meager, although from these the majority of *Dolichoderus* were taken. These ants nested between the leaves of dead *Typha* plants, and other species were in rotting wood. Two *Myrmicae* (*brevinodis* and *brevispinosa*) actually nested in the bog mat and could be located usually by standing at one place until the sphagnum sank causing the ants to retreat to the surface ahead of the rising water.

Three sandy areas in the Chicago Region, each with certain distinctive features, have been described at some length (Lowrie, 1942). The classical strip of dunes along the southern and eastern shore of Lake Michigan is the most diversified, and was examined at Pine, Miller, Ogden Dunes, Dune Acres (Mineral Springs), and Tremont, Indiana, and at Lakeside, Michigan. It includes substantial plant and animal successions which correlate with changing physiographic conditions progressing inland from the lake (Cowles, Shelford, O. Park, Strohecker). The typical sequence at Ogden presents three levels of beach (lower, middle and storm beach), foredunes (formed by sand-binding grasses, *Ammophila* and *Calamovilfa*), cottonwood dunes (height correlated with this species of tree), Jack and white pine pioneer woodlands or meadows of *Andropogon*, black oak woodlands and in sheltered pockets behind the high sand, mesophytic forests of red-white oak, maple, basswood, et cetera, which approach closely the beech-maple climax. Outstanding examples of ants which parallel this series are (1) *Monomorium minimum*, *Lasius niger neoniger* and *Pheidole bicarinata* on the upper beach and the two subsequent pioneer stages, (2) *Iridomyrmex pruinosus analis*, *Paratrechina parvula* and *Crematogaster lineolata* in the evergreen zone, (3) a long list of species of which the *Formica pallidefulva* group is almost diagnostic for the black oak woodland, and (4) a group of ants similar to those in the beech-maple forest with the conspicuous addition of *Lasius flavus nearcticus* and *Formica truncicola obscuriventris* in the mesophytic ravine subclimax. Some species range over two or more of the plant associates, but we can recognize the following trends. Representatives of the tropical and somewhat xerophilous genera *Monomorium* and *Pheidole* are the predominant species in the hot, semi-arid conditions of the open sand whether on the usual dune sequence or in stations where the plant cover has been removed and the dunes rejuvenated. Typical deciduous forest members increase directly with the increase of mesophytism, and an abrupt change of this sort is noted in passing from the pines into the oaks. The occasional presence of *pallidefulva* species in the pine



FIG. 3. Mixed oak forest and vernal pond at Palos Park, Illinois.  
Photo by Ecology Class, 1933.



FIG. 4. The Gary Ponds. View eastward from the embankment of the Elgin, Joliet and Eastern Railroad where it crosses Highway Twelve, showing the successional series of parallel ridges and depressions formed in Lake Chicago as sand bars and land-locked pools. Photo by Ecology Class, 1938.

woods may be an indication of environmental changes among the pines which culminate in their replacement by black oaks. Many of these tendencies are observable in Table I.

At Tremont the subclimax is well developed over much of the State Park, but the succession seems to be partially destroyed by an eroding shore which has reached far enough to expose some of the mesophytic forests on old established dunes. The lush growth ends sharply above steep, lakeward slopes with foredunes at the base. At Lakeside undercutting and slumping from wave action have produced high cliffs of sand which stand sixty to eighty feet above the water. The pattern in the Indiana dunes is further complicated by blowouts in which the terrestrial succession may start anew, and if the surface has been lowered beyond the water-table, pannes of open water and marshes develop.

Near Pine, Indiana, the ant species are identical with those in the pioneer stages of the other dune localities. The series of linear ponds alternating with former sand bars of Lake Chicago is still intact, but it is lamentable the first three or four of these have been filled by steel mill wastes. As previously noted, some of the oldest ponds which are now drying cattail swamps were visited at Hammond.

In the dunes of the Kankakee River basin ten miles south of Momence, Illinois, the ants are very similar to those of the other black oak forests on sand, but *Pheidole morrisi*, *Formica pallidefulva schaufussi* and *Formica sanguinea subintegra* are unusually abundant. The dunes are low and the vegetation consists of oak woods and meadows of mixed grasses.

Along the shore north of Waukegan, Illinois, the ants are again similar to those of the Indiana and Kankakee dunes except that *Formica neogagates* is considerably more abundant and the rare *Lasius latipes* was secured there. Almost all records of *Pheidole pilifera* were obtained from this station also. The vegetation is characterized by sand-binding grass, black oak ridges, Scotch pine and spreading marshes.

Within the various forest habitats are several strata, but only the subterranean and ground strata are important as places of abode for ants. They search in the trees for aphid honey-dew and capture much insect prey, but unlike tropical and subtropical species, seldom seem to build nests above the ground. Colonies either have galleries in the soil with craters or masonry domes at the surface, or are log inhabiting. Frequently, underground nests open beneath the protection of bark fragments, sticks or boards. Hypogaecic species are to be expected under stones or boulders. One colony of *Leptothorax* was found in the bark of a live tree, and this genus occasionally uses the fallen acorns of black oaks. The subterranean yellow *Lasius* forage actively above ground at Smith during the nocturnal period, and species of *Camponotus* are also abroad in great numbers at night.

The log niche is well occupied in forest and woodland, and runways may be excavated partly in soil and log. A number of stages in the process of wood decay can be recognized. Shelford designated four (1913, pp. 238, 246), while Talbot lists six and for the most part these may be adhered to. Stage 1 (dead tree still intact), Stage 2 (bark loosened), Stage 3 (sapwood soft), Stage 4 (heartwood soft), Stage 5



FIG. 5 Black oak dunes in Kankakee County near Momence, Illinois.  
Photo by R. W. Miller

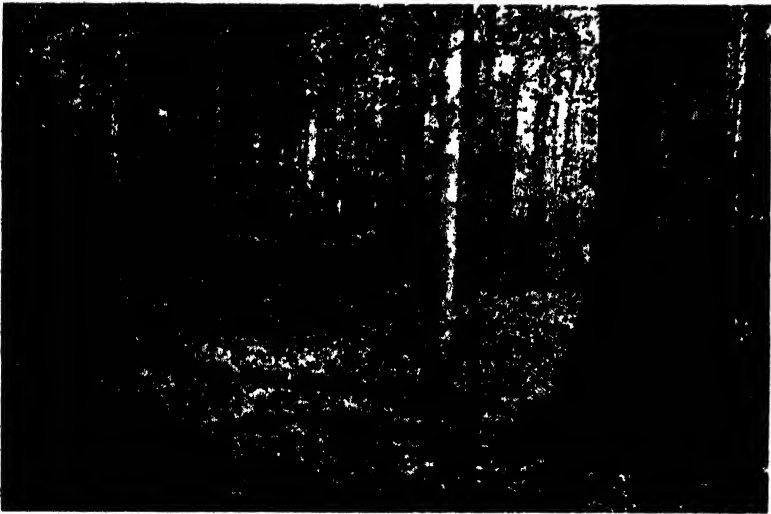


FIG. 6. Beech-maple forest at Warren Woods near Lakeside, Michigan.  
Photo by Ecology Class, 1940.

(log crumbling), Stage 6 (merging with soil). Though a single ant species may be present in more than one stage, the following list serves to show that in logs the optimum conditions for different forms vary directly as the wood disintegrates, and indeed, this process is often hastened by the ants themselves. *Crematogaster lineolata* and *C. l. cerasi* are common types in the early phases. *Camponotus herculeanus* spp. alone seem able to tunnel in live trees or fresh wood, and in logs all *Camponotus* remain until the wood is honeycombed but not collapsed. *Aphenogaster fulva* spp. and *A. tennesseensis* with *Formica fusca subaenescens* also are most frequent in the middle stages of the succession. There is a tendency for hypogaecic species (which regularly require a moist environment) to be present in the middle and late stages when the wood is wet and spongy. Examples of these are the *Lasius umbratus* group and *Ponera coarctata pennsylvanica* (Table II).

These stages in log decay are convenient categories, but instances are encountered where it is arbitrary to assign a stage as the process is a continuous one. Phases three, four and five are the most confusing, and different sections of a large log show varying degrees of decomposition. Savely (1939) describes a fairly close connection between the stage of decay and the number of years duration of the process, but one difficulty lies in the fact that the rate of disintegration varies decidedly with different woods.

The delineation of ant-plant communities can be ascertained from the accompanying tabular data. Since ants are closely associated with soil and are somewhat fixed in position by rather permanent nest locations, it follows that modification of the ground stratum by the plant cover automatically affects the tolerances of ant species. In the list presented below the communities are labeled by the ant names most characteristic of them. Common and widely distributed species are not considered good indices.

#### ANT-PLANT COMMUNITIES

**Prairie-meadow-pasture:** *Formica cinerea neocinerea* and *Myrmica lobicornis fracticornis* community.

**Foredune-cottonwood:** *Monomorium minimum* and *Pheidole bicarinata* community.

**Coniferous dune:** *Iridomyrmex pruinosus analis* and *Paratrechina parvula* community.

**Black oak dune:** *Formica pallidefulva* spp., *Aphaenogaster treatae* and *Leptothorax texanus* community.

**Mesophytic dune ravine forest:** *Formica truncicola obscuriventris* and *Lasius flavus nearcticus* community.

**Mixed oak forest:** *Prenolepis imparis* and *Stenamma brevicorne* community.

**Oak-hickory forest:** *Camponotus herculeanus pennsylvanicus ferrugineus* community.

**Beech-maple forest:** *Aphaenogaster fulva* spp., *Myrmecina graminicola americana* and *Leptothorax longispinosus* community.

**Bog forest:** *Myrmica brevinodis* spp. and *Dolichoderus* spp. community.

**Floodplain forest:** *Strumigenys pergandei* community.

**Forest margin:** This community appears to be too variable to have any ant species restricted to it. (See discussion of *F. ulkei*.)

**Marsh:** Has only sporadic colonies of ants and none characteristic.

**Railway and roadside:** These habitats may be considered special extensions of the prairie and forest margin communities.

The importance of sand versus clay in the Chicago Region is not neglected but the differences among vegetation types are emphasized.

In the later stages of plant succession the nature of the soil (so modified by the plant types) probably has a minor effect upon the distribution of ants. Many species are log or humus dwellers and are thus removed

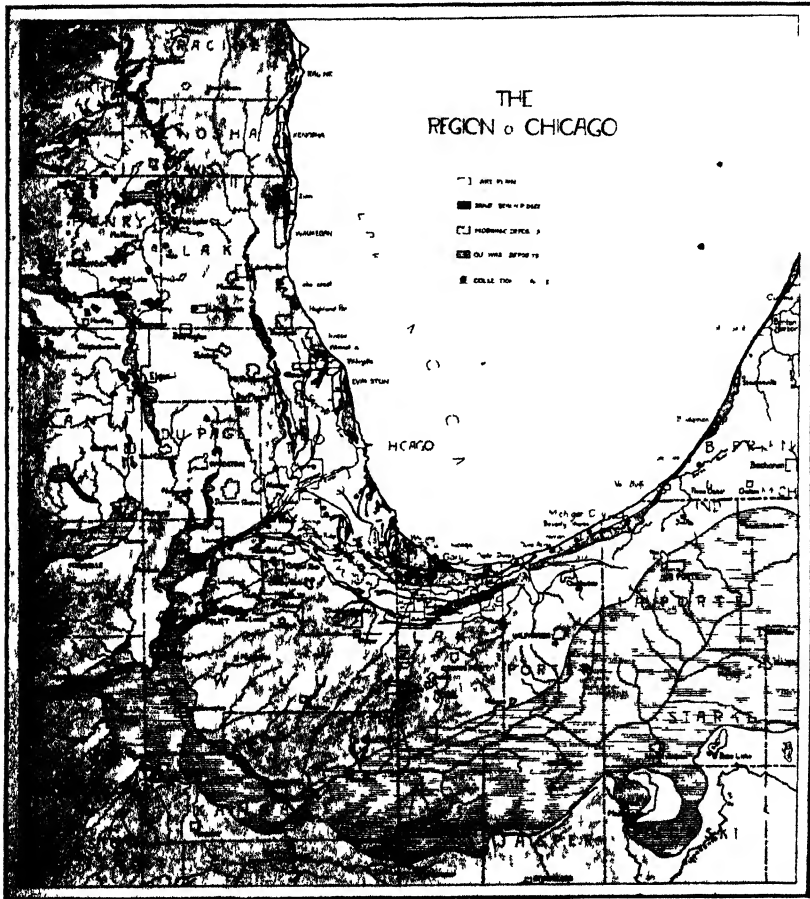


FIG. 7 The Region of Chicago. Permission has been granted to use this modification of "Plate I" from F. M. Fryxell's, "The Physiography of the Region of Chicago," published by the University of Chicago Press. (Three Rivers, Michigan, is too far east to be conveniently included on this map, and La Salle, Illinois, and Madison, Wisconsin, are too far west, but all are legitimately cited as localities for the region.)

from direct contact with the mineral substratum. Of the sixty-one ants present in black oak dunes and mixed oaks on clay, twenty-three species (37.7%) are common to both forests despite wide differences in soil. In comparing the sixty ants present in black oak dunes and





TABLE I—(Continued)

SPECIES	Prairie	Meadow	Pasture, Field	Forest margin	Foredune	Tottonwood dune	Jack pine dune	Black Oak dune	Mesophytic ravine	Oak Forest	(Oak-hickory Forest)	Beech-maple Forest	Placidplain Forest	Marsh	Box Forest	Railway and Roadside	House	Log Stages	Under Stones, Logs, etc.	Abundance
46. <i>Camponotus caryae subbarbatus</i> . . . . .																		3	1	R
47. <i>Camponotus castaneus</i> . . . . .																		3		D
48. <i>Camponotus castaneus emarginatus</i> . . . . .																		3		U
49. <i>Camponotus herculeanus ligularis boreboracensis</i> . . . . .																		2		C
50. <i>Camponotus herculeanus pennsylvanicus</i> . . . . .																		2		A
51. <i>Camponotus herculeanus pennsylvanicus ferrugineus</i> . . . . .																		2		D
52. <i>Camponotus herculeanus pennsylvanicus ferrugineus</i> . . . . .																		2		A
53. <i>Formica crenata cinerea neocivica</i> . . . . .																		2		D
54. <i>Formica exsectoides exsectoides</i> . . . . .																		2		A
55. <i>Formica fusca fusca subnervosa</i> . . . . .																		2		D
56. <i>Formica fusca fusca subsericea</i> . . . . .																		2		A
57. <i>Formica neogagates neogagates</i> . . . . .																		2		D
58. <i>Formica neogagates lasionides velula</i> . . . . .																		2		A
59. <i>Formica neoplicula</i> . . . . .																		2		D
60. <i>Formica pallidula pallidula</i> . . . . .																		2		A
61. <i>Formica pallidula pallidula</i> . . . . .																		2		D
62. <i>Formica pallidula pallidula</i> . . . . .																		2		A
63. <i>Formica pallidula pallidula</i> . . . . .																		2		D
64. <i>Formica rufa aggerans melanotica</i> . . . . .																		2		A
65. <i>Formica sanguinea aspera</i> . . . . .																		2		D
66. <i>Formica sanguinea rubicunda</i> . . . . .																		2		A
67. <i>Formica sanguinea subintegra</i> . . . . .																		2		D
68. <i>Formica sanguinea submunda</i> . . . . .																		2		A
69. <i>Formica truncicola integra</i> . . . . .																		2		D
70. <i>Formica truncicola obscuriventris</i> . . . . .																		2		A
71. <i>Formica truncicola obscuriventris</i> . . . . .																		2		D
72. <i>Formica ulkei</i> . . . . .																		2		A
73. <i>Lasius claviger</i> . . . . .																		2		D
74. <i>Lasius claviger</i> . . . . .																		2		A
75. <i>Lasius claviger</i> . . . . .																		2		D
76. <i>Lasius claviger</i> . . . . .																		2		A
77. <i>Lasius interclusus</i> . . . . .																		2		D
78. <i>Lasius interclusus</i> . . . . .																		2		A
79. <i>Lasius niger</i> . . . . .																		2		D
80. <i>Lasius niger</i> . . . . .																		2		A
81. <i>Lasius umbrinus misticus aphidicola</i> . . . . .																		2		D
82. <i>Lasius umbrinus misticus aphidicola</i> . . . . .																		2		A
83. <i>Lasius umbrinus misticus aphidicola</i> . . . . .																		2		D
84. <i>Lasius umbrinus misticus aphidicola</i> . . . . .																		2		A
85. <i>Polyrhagus ruficornis brevicornis</i> . . . . .																		2		D
Total	8	9	18	17	7	5	12	47	15	37	19	25	18	5	15	4	2			
Percentage	9	4	10	6	21	20	0	8	2	6	0	14	1	55	3	17	6	4	7	2

beech-maple forest on silt and clay, twelve (or 20%) are common to both despite wide differences in soil. The reduction in the percentage of common forms between these two habitats seems to parallel important differences in vegetational type. *Prenolepis imparis*, though noticeably dependent on the clay of morainic oak woodland for the construction of domed galleries, has been found also in the oak dunes. Oak forests, regardless of type, have the richest assemblage of species, and this might be traced to the variety of niches. Much humus is present, trees and shrubs add important strata, logs are numerous, yet openings appear where meadow conditions develop and there are even patches of bare earth.

TABLE II

	USE OF LOGS BY ANT SPECIES					
	1	2	3	4	5	6
Stage of decomposition						
Number of ant species	4	17	29	24	20	3
Percentage	10 0	42 5	72 5	60 0	50 0	7.5

TABLE III

	ABUNDANCE OF ANT SPECIES			
	A Abundant	C Common	U Uncommon	R Rare
Density of ant species				
Number of ant species	9	19	31	26
Percentage	10 6	22 3	36 5	30.6

### GEOGRAPHIC ORIGINS

The upper Mississippi Valley is similar in species composition to the St. Lawrence Drainage and the North Atlantic States. Most of the ant species in Connecticut, for instance, are found at least as far west as Illinois, Indiana and Wisconsin, and others cross the continent. *Formica*, *Lasius*, *Myrmica*, *Stenamma* and *Polyergus* which are Holarctic, and *Camponotus* which is cosmopolitan, contain over half (48) of the species known for the area. Nevertheless, the vegetational transitions in the Chicago Region are matched by ant species or genera with overlapping ranges. Some western members of the above genera have spread into Illinois, and several species have migrated southward from the Canadian Zone. A noteworthy southern invasion is represented by thirteen genera (of the twenty-five listed for Chicago) which are tropical in distribution. Since some of these are large groups with many tropical forms described, the one or few species in each characterizing our fauna indicates that these genera are near the limit of their northern penetration. Illustrations of the zoogeographic trends are briefly outlined below. Consult Wheeler's works (1917b, etc.) for the distribution of North American Formicidae.

## From the East:

Several eastern species seem to be rarer in the middle west.  
 Ex. *Formica exsectoides* and *Lasius (A.) claviger*.  
*Tetramorium caespitum* (introduced from Europe).

## From the West:

*Formica cinerea neocinerea*.  
*Polyergus rufescens breviceps*.  
*Myrmica brevinodis brevispinosa*.

## From the North:

*Formica ulkei*.  
*Camponotus herculeanus ligniperda noveboracensis*.

## From the South:

<i>Pheidole</i> (t)	<i>Leptothorax</i>	<i>Stigmatomma</i>
<i>Solenopsis</i> (t)	<i>Iridomyrmex</i>	
<i>Crematogaster</i> (t)	<i>Dorymyrmex</i>	
<i>Monomorium</i> (t)	<i>Dolichoderus</i>	
<i>Strumigenys</i> (t)	<i>Ponera</i>	
<i>Aphaenogaster</i>	<i>Proceratium</i>	

(All these genera are tropical; "t"—tropicopolitan.)

*Myrmica brevinodis sulcinodoides* Emery and *Formica perpilosa* Wheeler have been listed for the area by Talbot but I have not relocated them. *Camponotus caryae caryae minutus* Emery is difficult to distinguish from *nearcticus* and may not deserve formal recognition. *Iridomyrmex humilis* Mayr was present at the University Laboratory in 1934 but it has not been seen in recent years.

In addition to the seventy ants recorded by Dr. Talbot, twenty-two others have been collected, and doubtless more remain undiscovered. The following keys modified from various papers by Wheeler (1903a, b, 1905, 1910a, b, c, 1913, 1916, 1922), Smith (1931, 1936) and Cole (1940), trace the species represented in the author's collection.

## Formicidae

## KEY TO THE SUBFAMILIES\*

1. Anal opening circular and terminal, usually bounded by a fringe of curved hairs (p. 469) . . . . . **FORMICINAE**
2. Anal opening a narrow slit, ventral in position . . . . . 2
2. Pedicel composed of two segments; sting usually well developed (p. 460),  
     Pedicel of only one segment . . . . . **MYRMICINAE** 3
3. A marked constriction between the first and second gastric segments  
     (p. 459) . . . . . **PONERINAE**
- No constriction between the gastric segments; anal slit transverse (p. 467),  
     . . . . . **DOLICHODERINAE**

## Ponerinae

## KEY TO THE GENERA

1. Abdomen strongly decurved and pointing somewhat forward (p. 460),  
     . . . . . **Proceratium**
- Abdomen of the usual shape (not decurved) . . . . . 2
2. Mandibles triangular, teeth minute (p. 460) . . . . . **Ponera**
- Mandibles linear, teeth conspicuous and bidenticulate (p. 460) . . . . . **Stigmatomma**

\*Key to the workers. The subfamilies Cerapachyinae, Dorylinae and Pseudomyrmecinae are not represented in the Lake Region.

**Proceratium Roger**

*Proceratium croceum* (Roger).—The single record of this species was obtained by Mr. Henry Dybas near the periphery of the area. Its presence beneath dung appears unusual as it is expected to occur in old logs.

Localities: Hamlet, Ind. (Dybas).

**Stigmatomma Roger**

*Stigmatomma pallipes* (Haldeman).—In the few places where I have collected this ant it seems always to be restricted to woodland areas and to be either in logs or under them. Two records of its occurrence are with other ants or at least in their immediate vicinity, namely: *Lasius* (*A.*) *claviger* and *Formica ulkei*. One specimen was found in cow dung. None but isolated individuals have been secured in each case despite efforts to locate the nests.

Localities: Palos Park, Ill. (R. Wheeler, Gregg); Ogden Dunes, Ind. (Lowrie, Gregg); Hamlet, Ind. (Dybas); Three Rivers, Mich.

**Ponera Latreille****KEY TO THE SPECIES**

Color brownish black; external borders of mandibles straight (p. 460),

*coarctata pennsylvanica* Buckley

Color ferruginous yellow; external borders of mandibles sinuate (p. 460),

*inexorata* Wheeler

*Ponera coarctata pennsylvanica* Buckley.<sup>4</sup>—In contrast to *Stigmatomma*, this ant is very common in certain habitats. The greatest number of nests was found in deep woods where the galleries ramified under bark or beneath the moss covering old logs. In one instance, many colonies were taken from under flat stones in a pasture. Winged males and females can be obtained in the latter part of August and early September.

Localities: New Lenox, Ill.; Hadley, Ill.; Palos Park, Ill.; Orland Park, Ill.; Momence, Ill.; Waukegan, Ill.; Volo, Ill.; Carlé Woods, Ill. (O. Park); Hodgkins, Ill. (Miller); Chicago, Ill. (Miller); Chesterton, Ind.; Smith, Ind.; Starke Co., Ind. (Dybas); Lakeside, Mich.

*Ponera inexorata* Wheeler.—According to Smith, this ant ranges from "Costa Rica through Mexico into the southern section of the United States." Its presence so far north seems difficult to explain, but its distribution is as yet uncertain owing to the meagre records of its occurrence. Its yellowish color serves easily to distinguish it.

Localities: Lake Geneva, Wis. (Lowrie).

**Myrmicinae****KEY TO THE GENERA**

1. Antennae 6-jointed; head cordiform (p. 461) . . . . . **Strumigenys**  
Antennae with more than six joints . . . . . 2
2. Antennae 10-jointed, with a club composed of two joints (p. 461) . . **Solenopsis**  
Antennae 11- or 12-jointed . . . . . 3
3. Postpetiole articulated to the dorsal surface of the gaster which is dorsally flattened and pointed at the tip (p. 461) . . . . . **Crematogaster**  
Postpetiole articulated in the usual place at the anterior end of the gaster . . 4

<sup>4</sup>Unless otherwise stated, the third name in trinomials is subspecific.

4. Posterior margin of clypeus elevated into a ridge bordering the antennal fossa ..... 5  
Posterior margin of clypeus not thus elevated ..... 6
5. Portion of clypeus in front of antennal fossa very narrow and reduced to a mere ridge (p. 462) ..... **Myrmecina**  
Portion of clypeus in front of antennal fossa narrow but not reduced to a mere ridge (p. 462) ..... **Tetramorium**
6. Workers strongly dimorphic (worker and soldier castes); antennae with a 3-jointed club (p. 462) ..... **Pheidole**  
Workers monomorphic; antennal club indistinct or not longer than the remainder of the funiculus ..... 7
7. Last three antennal joints shorter than the remainder of the funiculus, and not forming a distinct club ..... 8  
Last three antennal joints about equal to the remainder of the funiculus, and forming a distinct club ..... 10
8. Posterior tibial spurs pectinated; body coarsely sculptured (p. 463) ..... **Myrmica**  
Posterior tibial spurs not pectinated; body smooth or finely sculptured ..... 9
9. Small, hypogaecic species with vestigial eyes and two keels on the clypeus, (p. 464) ..... **Stenamma**  
Medium sized epigaecic species with well developed eyes and no clypeal keels (p. 465) ..... **Aphaenogaster**
10. Clypeus armed with a pair of ridges which project forward in the form of teeth; epinotum without spines or teeth (p. 466) ..... **Monomorium**  
Clypeus unarmed; epinotum armed with spines or teeth (p. 466) ..... **Leptothorax**

### **Strumigenys F. Smith**

*Strumigenys* (*Cephaloxys*) *pergandei* Emery.—Eleven specimens form a single record of this minute ant taken from the same rotting log as a large colony of *Lasius umbratus mixtus aphidicola*. The galleries of the two species were in very close proximity but it could not be ascertained whether they intercommunicated. The habitat is a flood-plain forest with a rather wet floor, and the nests were located in the upper side of the log.

Localities: Chesterton, Ind. (Talbot, Gregg).

### **Solenopsis Westwood**

*Solenopsis* (*Diplophoptrum*) *molesta* (Say).—This species is discovered frequently in the mound nests of *Formica ulkei* and *Formica exsectoides* where it occupies minute galleries tunneled in the walls separating the runways of the larger species. Of special interest is the disparity in size of the castes; the female is many times larger than her worker progeny. This condition has been traced to the lestopibiotic tendencies of the insect. It is by no means dependent upon the thieving habit for sustenance, however, as flourishing nests with numerous alate females have been observed far from any large host species.

Localities: Waukegan, Ill.; Palos Park, Ill.; Chicago, Ill.; New Lenox, Ill.; Momence, Ill.; Dune Acres, Ind.; Three Rivers, Mich.; Lakeside, Mich.; Ogden Dunes, Ind.

### **Crematogaster Lund**

#### **KEY TO THE SPECIES**

- Dark brown to piceous black in color; hairs on thoracic dorsum numerous (p. 462) ..... **lineolata** Say  
Paler in color, thorax reddish; hairs on thoracic dorsum restricted to the humeral angles (p. 462) ..... **lineolata cerasi** Fitch

*Crematogaster lineolata* Say.—With one exception this ant was found in dry, open woodland of the pine or black oak types, and it is a common inhabitant of the middle stages of log decay. Judging from the specimens in the collection, it is not as frequently encountered nor does it occur in as many seral units as the next species. Winged males have been captured in October.

Localities: Momence, Ill.; Waukegan, Ill.; Miller, Ind.; Dune Acres, Ind.; Ogden Dunes, Ind.; Lakeside, Mich.

*Crematogaster lineolata* var. *cerasi* Fitch.—Present in most environments from pasture to climax forest and all but the earliest and latest periods in the disintegration of logs or stumps. Laboratory populations of these *Crematogasters* have built small quantities of carton from pieces of moist sponge placed in the nests, but in the field no indications of aerial construction have been detected. A closely related species in Florida (*Crematogaster atkinsoni* Wheeler) makes a nest of paper, and one of these, sent through the courtesy of Dr. E. Morton Miller, when examined measured approximately six inches in diameter.

Winged males and females are present in the nests of *cerasi* during July, August, September and October.

Localities: New Lenox, Ill.; Volo, Ill.; Palos Park, Ill.; Chicago, Ill.; Waukegan, Ill.; Momence, Ill.; Orland Park, Ill.; Dune Acres, Ind.; Smith, Ind.; Valparaiso, Ind. (Lowrie, Gregg); Ogden Dunes, Ind.; Chesterton, Ind.; Starke Co., Ind. (Dybas); Three Rivers, Mich.; Lakeside, Mich.

### Myrmecina Curtis

*Myrmecina graminicola americana* Emery.—This small and sluggish ant seems to be restricted to sheltered spots, particularly climax and subclimax forests where much shade exists. The colonies are small, and a few workers were gathered from such moist places as the underside of wood and the late stages of log decay. The species is rare for the Chicago Area, but Cole found that it is rather common in the buckeye-basswood forests of the Smoky Mountains.

Localities: Ogden Dunes, Ind. (Lowrie, Gregg); Chesterton, Ind.; Lakeside, Mich.; Smith, Ind. (Miller).

### Tetramorium Mayr

*Tetramorium caespitum* Linnaeus.—It is an introduced European form and though common in some parts of the East, my collections indicate that it is still rare in the region about the head of Lake Michigan.

Localities: Chicago, Ill.

### Pheidole Westwood<sup>5</sup>

#### KEY TO THE SPECIES

1. Epinotal spines reduced to low tubercles; color yellowish red (p. 463) . . . *morrisi*  
Epinotal spines well developed; brownish red to black . . . . . 2
2. Head of soldier very large, coarsely sculptured throughout (p. 463) . . . *pilifera*  
Head of soldier smaller, posterior portion smooth and shining . . . . . 3

<sup>5</sup>Soldiers are necessary for the adequate determination of *Pheidole* species, and the key is based on this caste.

3. Epinotal declivity with transverse striae; antennal scape long (p. 463),  
 Epinotal declivity smooth; antennal scapes shorter than in *bicarinata* (p. 463),  
*bicarinata*  
*vinelandica*

*Pheidole morrissi* Forel.—Nests of this species are present in the various dunelands but they are abundant only in the black oak woods south of Momence. The formicaries are very populous, and upon being disturbed the ants swarm out in large numbers to defend themselves. An excellent aggregation of colonies was found in a blowout of one of the dunes, and each nest was placed among the roots of a grass hummock. Winged males were collected in August and females were present as early as June.

Localities: Momence, Ill.; Miller, Ind.; Dune Acres, Ind.

*Pheidole pilifera* (Roger).—The huge heads of the soldier make this ant especially striking in the field. Its powerful jaws supposedly serve to crush the seeds that are gathered and stored by the workers in the galleries of the nest. Except for one doubtful instance, all collections of the species have been in dune areas. The nest entrances were surrounded by craters as a rule larger than those of *Lasius*, and this usually helps to distinguish them from the latter.

Localities: Waukegan, Ill.; Momence, Ill.

*Pheidole bicarinata* Mayr.—It appears in a greater variety of habitats than either of the other *Pheidole* although it is restricted to sand or sand humus substrata. Several log stages and the underside of rotting wood are also included in its places of abode. Minute nest entrances marked by little or no crater deposits were located on the foredunes among shoots of marram grass. Their occurrence is fairly frequent.

Localities: Waukegan, Ill.; Momence, Ill.; Pine, Ind.; Miller, Ind.; Ogden Dunes, Ind.; Dune Acres, Ind.; Tremont, Ind.; Lakeside, Mich.

*Pheidole vinelandica* Forel.—This form is very close to *bicarinata* but can be distinguished from it by the characters mentioned in the key. It is recorded for the area by Dr. Talbot but is much rarer than the former species and does not occupy as many of the dune associates. At present I have obtained no specimens within the confines of the Chicago Region.

### *Myrmica* Latreille

#### KEY TO THE SPECIES

- |  |                                |
|--|--------------------------------|
| 1. Antennal scapes evenly bent at the base. . . . .  | 2                              |
| Antennal scapes sharply angled at the base. . . . .  | 4                              |
| 2. Gaster with hairs set in distinct punctures (p. 464) . . . . .                            | <i>punctiventris</i>           |
| Gaster not punctate. . . . .   | 3                              |
| 3. Epinotal spines short, not longer than their distance apart at the base (p. 464). . . . . | <i>brevinodis brevispinosa</i> |
| Epinotal spines longer than their distance apart at the base (p. 464), . . . . .             | <i>brevinodis brevinodis</i>   |
| 4. Angle of antennal scape with a lateral, tooth-like projection (p. 464), . . . . .         | <i>lobicornis fracticornis</i> |
| Angle of scape possessing a transverse ridge or lamina across the bend (p. 464). . . . .     | <i>sabuleti americana</i>      |
| Angle of scape expanded into a broad, spatulate flange (p. 464), . . . . .                   | <i>schencki emeryana</i>       |



*Myrmica lobicornis fracticornis* Emery.—One of the commonest myrmicines in the area, and it is apparently well adapted to either sand or clay substratum. The nest entrances are obscure although small craters are at times constructed, and colonies of considerable size are frequently unearthed. Under stones and beneath decaying wood are suitable nest sites; one colony was collected from the interior of an *ulkei* formicary. Their slow and deliberate movements and dark, earthy coloration make these ants inconspicuous against most soil backgrounds.

Localities: Palos Park, Ill.; New Lenox, Ill.; Waukegan, Ill.; Volo, Ill. (Miller); Momence, Ill. (Lowrie); Dune Acres, Ind. (Lowrie).

*Myrmica sabuleti americana* Weber.—At all but one station this species was found living on dune sand. The Chesterton specimens were obtained in a lush pawpaw thicket growing on alluvial deposits. The coloration of this ant is somewhat lighter and more reddish brown than the preceding species, and its epinotal spines are distinctly longer.

Localities: Waukegan, Ill. (Lowrie, Gregg); Momence, Ill. (Lowrie, Gregg); Miller, Ind.; Tremont, Ind.; Chesterton, Ind.

*Myrmica schencki emeryana* Forel.—As indicated in the key, this ant is distinguished by the pronounced enlargement of the antennal angle, but the color and sculpture are very similar to *lobicornis*. The species seems to show no decided preference for either sand or clay soil although it is found usually in moist woodland and nests under stones or wood.

Localities: Dune Acres, Ind. (Lowrie, Gregg); Ogden Dunes, Ind. (Lowrie); Chesterton, Ind.; Volo, Ill.; Lake Geneva, Wis. (Lowrie).

*Myrmica brevinodis brevinodis* Emery.—According to my collections, this ant and the following species have a circumscribed distribution in the area. They are common only in a bog of the lake district where they inhabit the sphagnum mat, and the subspecies *brevinodis* was also secured from the fields adjacent to the bog. No nests were constructed in the swamp as the ants merely occupied the interstices of the mat.

Localities: Volo, Ill.; Miller, Ind.; Tremont, Ind.; Lakeside, Mich.

*Myrmica brevinodis brevispinosa* Wheeler.—All specimens were taken in the bog, and certain of them had been trapped in a pitcher plant.

Localities: Volo, Ill. (Miller, Gregg).

*Myrmica punctiventris* Roger.—Easily distinguished by the coarse punctures on the base of the gaster. The color is dark brown, the sculpture heavy and the epinotal spines long and sharp. It lives in climax and subclimax forests but does not seem to be abundant in them. Late stages of log decay are included as suitable nesting sites.

Localities: Carlé Woods, Ill. (O. Park); Smith, Ind.; Lakeside, Mich.

### **Stenamma** Westwood

#### KEY TO THE SPECIES

Larger forms (2.5–4 mm.); body dark brown, base and tip of gaster yellowish; eye with more than four ommatidia in its greatest diameter (p. 465). . **brevicorne**  
 Smaller forms (2.4–3 mm.); body reddish brown; eye very small, with not more than three or four ommatidia in its greatest diameter (p. 465). . **brevicorne schmittii**

*Stenamma brevicorne* Mayr.—This is a small, hypogaecic ant living in logs or under the surface of leaf mold on the forest floor. Its colonies are small and quite uncommon. Winged males and females were taken from one nest in September.

Localities: Waukegan, Ill.; Palos Park, Ill.; Carlé Woods, Ill. (Park).

*Stenamma brevicorne schmittii* Wheeler.—The small size of the eye is the best means to separate this subspecies from the typical *brevicorne*. It exhibits the same preference for mesic conditions as the latter, and according to the local records it occurs only in wooded dunes. Winged females were captured in October.

Localities: Miller, Ind.; Ogden Dunes, Ind. (Lowrie, Gregg).

### Aphaenogaster Mayr

#### KEY TO THE SPECIES

1. Antennal scape with long, flat lobe at the base; postpetiole markedly swollen (p. 465). . . . . **treatae**
- Antennal scape without such a lobe; postpetiole not swollen. . . . . 2
2. Head with posterior angles distinctly rounded (p. 465). . . . . **texana carolinensis**
- Head with posterior corners obtusely angled. . . . . 3
3. Epinotal spines at least as long as the base of the epinotum; color red (p. 465), **tennesseensis**
- Epinotal spines shorter than the base of the epinotum; color reddish brown to black. . . . . 4
4. Epinotal spines somewhat longer than half the base of the epinotum; length 4.5–5 mm. (p. 466). . . . . (typical) **fulva**
- Epinotal spines shorter than half the base of the epinotum; length 4–4.5 mm. . . . . 5
5. Color reddish brown (p. 466). . . . . **fulva aquia**
- Color pitchy black. . . . . **fulva aquia picea**

*Aphaenogaster treatae* Forel.—Black oak woodland of the several dunes seemed to be the only stations inhabited by this species. It tunnels in logs or the soil directly beneath them.

Localities: Dune Acres, Ind.; Miller, Ind.; Momence, Ill. (Lowrie, Gregg); Waukegan, Ill.

*Aphaenogaster texana* var. *carolinensis* Wheeler.—This ant belongs to a group with more southern distribution, and its occurrence in the Lake Region would seem unusual. A single colony has been discovered in a crumpling log of the climax forest, the habitat most common for other *Aphaenogasters*. Structurally, it might be confused with *fulva aquia* or its variation *picea*, but the rounded condition of the posterior part of the head is a dependable diagnostic character.

Localities: Lakeside, Mich.

*Aphaenogaster tennesseensis* Mayr.—A beautiful red species of large size. The formicaries are very populous and may be found in the early and middle stages of log disintegration. At least none have been located in soil devoid of decaying wood. These ants are thought to be temporary parasites on species of *Aphaenogaster fulva*. The diminutive queen of *tennesseensis* invades the host colony to become established, after which the host individuals gradually disappear and leave a thriving nest of her progeny. One dealated female (probably a young queen) was collected on November sixth, and two alate females were found with their colony in July.

Localities: New Lenox, Ill.; Palos Park, Ill.; Orland Park, Ill.; Hadley, Ill.; Hodgkins, Ill.; Miller, Ind. (Lamar); Smith, Ind. (Lowrie, Gregg); Lakeside, Mich.; Three Rivers, Mich.; Coloma, Mich. (Ivaska).

*Aphaenogaster fulva* Roger.—All members of the *fulva* group are insects of moist, shady situations, particularly climax and subclimax forests. They are almost invariably associated with wood, being either in the late stages of log succession or in the leaf litter and soil under the log. Occasional colonies nest beneath stones. *A. fulva* is the rarest.

Localities: Palos Park, Ill.; Momence, Ill.; Dune Acres, Ind.; Tremont, Ind.; Smith, Ind.

*Aphaenogaster fulva aquia* (Buckley).—Localities: New Lenox, Ill.; Palos Park, Ill.; Volo, Ill.; Dune Acres, Ind.; Chesterton, Ind.; Smith, Ind.; Lakeside, Mich.

*Aphaenogaster fulva aquia picea* Emery.—Localities: Ogden Dunes, Ind.; Smith, Ind.; Lakeside, Mich.; Coloma, Mich. (Ivaska).

### Monomorium Mayr

#### KEY TO THE SPECIES

Clypeal teeth prominent; length 1.5–2 mm.; color black (p. 466) . . . **minimum**  
Clypeal teeth indistinct; length 2–2.3 mm.; color yellow (p. 466) . . . **pharaonis**

*Monomorium minimum* (Buckley).—In certain areas of the sand dunes this species is common, but, like *Solenopsis molesta*, it is so small and its colonies obscure that it is easily overlooked. A tiny crater may betray the nest opening although this is not a constant feature. Multiple queens are frequently observed in one colony, and up to twelve and fourteen have been recovered after excavation of complete nests. The species is especially adaptable to laboratory conditions. It will flourish in small plaster nests, and two to three thousand individuals may be reared if an abundance of insect meat is furnished.

Localities: Waukegan, Ill.; Momence, Ill. (Lowrie, Gregg); Ogden Dunes, Ind.

*Monomorium pharaonis* Linnaeus.—The ant is a house-infesting form in northern regions but originally came from "warmer regions of the Old World." Its distribution has become global. One record of this species (with the queen) was secured from a house in the city.

Localities: Chicago, Ill. (Sturtevant).

### Leptothorax Mayr

#### KEY TO THE SPECIES

1. Antennae 11-jointed . . . . . 2  
Antennae 12-jointed (p. 467) . . . . . **texasus**
2. Epinotal spines very short, dentiform; color deep brown to black (p. 467),  
**fortinodis**  
Epinotal spines long . . . . . 3
3. Color black; epinotal spines very long (p. 467) . . . . . **longispinosus**  
Color yellow; epinotal spines shorter . . . . . 4
4. Epinotal spines long, thin and curved; first gastric segment with two black  
or brown spots (p. 467) . . . . . **curvispinosus**  
Epinotal spines short and straight (p. 467) . . . . . **curvispinosus ambiguus**

*Leptothorax texanus* Wheeler.—Nowhere outside of black oak dunes was this ant found, and it appeared always to nest in the soil. Its presence in this habitat is probably correlated with its southern distribution.

Localities: Waukegan, Ill. (Lowrie, Gregg); Momence, Ill. (Lowrie, Gregg); Dune Acres, Ind. (Lowrie, Gregg).

*Leptothorax fortinodis* Mayr.—This species, like the following one, was observed in moist forested stations, and is an inhabitant of logs. One colony was discovered nesting in the bark of a live tree (Stage 1).

Localities: Chesterton, Ind.; Tremont, Ind.; Smith, Ind. (Kurtz, Gregg); New Lenox, Ill.

*Leptothorax longispinosus* Roger.—Beech-maple forest is the sole habitat for the species, according to the records, but I suspect that it may occur in other situations which approach the mesophytic environment of the forest. It is to be seen in most log stages.

Localities: Smith, Ind., Lakeside, Mich., Coloma, Mich. (Ivaska).

*Leptothorax curvispinosus* Mayr.—Of the several species in the area, this one is the most tolerant of conditions. It is distributed in a variety of communities, and occasionally occupies such special niches as fallen acorns and goldenrod galls. Rotting logs are also places of abode as would be expected. The small size of *Leptothorax* colonies and the individuals which compose them render their location difficult. Often, foraging workers can be gathered but the position of the nest is not revealed.

Localities: Palos Park, Ill.; Orland Park, Ill.; Hadley, Ill.; Momence, Ill. (Lowrie, Gregg); Dune Acres, Ind. (Lowrie); Chesterton, Ind. (Lowrie); Smith, Ind.; Lakeside, Mich.

*Leptothorax curvispinosus ambiguus* Emery.—Occurs in both woodland and prairie, but no instances of log dwelling were evident.

Localities: Palos Park, Ill.; Chicago, Ill.; Harvey, Ill.

## Dolichoderinae

### KEY TO THE GENERA

1. Integument hard and brittle; declivity of the epinotum strongly concave (p. 467).....**Dolichoderus**
- Integument thin and flexible; epinotal declivity not strongly concave..... 2
2. Petiolar scale vestigial or absent (p. 468).....**Tapinoma**
- Petiolar scale well developed..... 3
3. Epinotum with a conical elevation (p. 468).....**Dorymyrmex**
- Epinotum rounded, without a conical elevation (p. 468).....**Iridomyrmex**

## Dolichoderus Lund

### KEY TO THE SPECIES

1. Head and thorax with shallow foveolae, shining..... 2
- Head and thorax coarsely and deeply foveolate, subopaque..... 3
2. Epinotal concavity with a strong, median longitudinal ridge; head, thorax and petiole yellowish red (p. 468).....**mariae**
- Epinotal concavity without ridge; color brownish to black, base of gaster with reddish yellow spots (p. 468).....**plagiatus pustulatus**
3. Base of gaster with reddish yellow spots (p. 468).....**plagiatus**
- Gaster entirely black (p. 468).....**plagiatus inornatus**

*Dolichoderus (Hypoclinea) mariae* Forel.—A tamarack bog with open water in its center was practically the only place where species of this genus were obtained. To find members of a group with tropical distribution in a bog of this area (the organisms of which are relicts of a more northern fauna and flora) seems incongruous, but I am unable at present to offer an explanation. The colonies collected personally were in each case located in the stalk and between the leaves of dried *Typha*.

The rather striking species, *D. mariae*, is represented only by one specimen.

Localities: Volo, Ill.

*Dolichoderus (Hypoclinea) plagiatu* Mayr.—This ant appeared to be far less abundant than its variety which follows.

Localities: Volo, Ill. (Lowrie).

*Dolichoderus (Hypoclinea) plagiatu* var. *inornatus* Wheeler.—In addition to the tamarack bog, one collection of the species was made in a white oak woodland. This ant was present in noticeably greater numbers than any of the others in the genus.

Localities: Volo, Ill. (Lowrie, Schweitzer, Gregg); Ogden Dunes, Ind.; Dune Acres, Ind. (Lowrie).

*Dolichoderus (Hypoclinea) plagiatu pustulatus* Mayr.—Localities: Volo, Ill.

### **Tapinoma Förster**

*Tapinoma sessile* (Say).—This insect can be confused with the varieties of *Lasius niger*, but the slit-like anal opening and the low petiolar scale will always distinguish *Tapinoma*. Further, when handled *Tapinoma* raises the gaster and emits a whitish fluid that has the odor of cocoa butter, and this is the best field mark. The ants nest in a variety of natural communities, and are to be found in different log stages and under stones or debris.

Localities: Palos Park, Ill.; New Lenox, Ill.; Volo, Ill., Dune Acres, Ind.; Chesterton, Ind.; Smith, Ind.; Three Rivers, Mich.; Lake Como, Wis. (Lowrie).

### **Dorymyrmex Mayr**

*Dorymyrmex pyramicus* var. *flavus* McCook.—A single record of this ant is from dry duneland, and the specimens were living with or near a colony of *Pheidole pilifera*. The species *pyramicus* is known to associate itself with colonies of *Pogonomyrmex* in the western states, and it is said to appropriate some of the food of the latter form to its own use. The occurrence of *flavus* in the Great Lakes Region probably represents a portion of the northern limit of the range of the species.

Localities: Waukegan, Ill.

### **Iridomyrmex Mayr**

#### **KEY TO THE SPECIES**

Head and thorax brownish, gaster light yellow (p. 468).....**pruinosis analis**  
 Head, thorax and gaster reddish brown (p. 469).....**humilis**

*Iridomyrmex pruinosus* var. *analis* (André).—It seems to be confined to black oak and Jack pine dunes, and is very active over the arid sand

of these areas. Craters are constructed which are almost identical with those of *Lasius*.

Localities: Momence, Ill.; Ogden Dunes, Ind.

*Iridomyrmex humilis* Mayr.—The Argentine ant. It is now cosmopolitan, having spread from its home in South America, and infests houses especially in the cooler parts of its range. It has not been taken from the natural environments about Chicago, but Dr. Talbot collected it from the zoological laboratory at the University. It has since disappeared, and the author was unable to get samples. The head of *humilis* has a peculiar, subtriangular shape, and this serves further to separate it from *pruinus* in which the head is subrectangular.

### Formicinae

#### KEY TO THE GENERA

- |  |                     |   |
|--|---------------------|---|
| 1. Antennae 9-jointed (p. 469) . . . . .   | <b>Brachymyrmex</b> | 2 |
| 2. Antennae with more than nine joints . . . . .   |                     |   |
| Workers strongly polymorphic; anterior portion of thorax flattened dorsally, and triangular in outline when viewed from above (p. 477) . . . . . | <b>Camponotus</b>   |   |
| Workers monomorphic or sometimes variable in size; thorax constituted differently . . . . .  |                     | 3 |
| 3. Clypeal fossa distinctly separate from antennal fossa . . . . .   |                     | 4 |
| Clypeal fossa confluent with antennal fossa . . . . .  |                     | 5 |
| 4. Body covered with long, stiff hairs; mesonotum constricted but not sub-cylindrical (p. 469) . . . . .   | <b>Paratrechina</b> |   |
| Body with only delicate, flexible hairs; mesonotum constricted and sub-cylindrical in shape (p. 469) . . . . .                                   | <b>Prenolepis</b>   |   |
| 5. Joints 2-5 of funiculus shorter or not longer than the succeeding joints; ocelli usually absent (p. 470) . . . . .                            | <b>Lasius</b>       |   |
| Joints 2-5 of funiculus longer than the remaining joints; ocelli present . . . . .   |                     | 6 |
| 6. Mandibles with broad, dentate apical border (p. 472) . . . . .  | <b>Formica</b>      |   |
| Mandibles narrow, falcate and pointed (p. 476) . . . . .   | <b>Polyergus</b>    |   |

### Brachymyrmex Mayr

*Brachymyrmex heeri depilis* Emery.—It is distributed in woodland and forest margin, nesting in the soil directly or under stones. In size it ranks among the smallest, and the shortness of the antennae easily sets it apart from other ants in the region.

Localities: Palos Park, Ill.; Chicago, Ill. (Windsor); Dune Acres, Ind.

### Paratrechina Motschoulsky

*Paratrechina (Nylanderia) parvula* (Mayr).—In logs and under debris in sandy habitats. Its long setae readily isolate it from any other ant in the area. *Lasius niger* is the main species with which it might be confounded.

Localities: Waukegan, Ill.; Momence, Ill.; Ogden Dunes, Ind.; Dune Acres, Ind.

### Prenolepis Forel

#### KEY TO THE SPECIES

- Body piceous black, mandibles, antennae, tibiae and tarsi lighter (p. 470). . . . . **imparis**  
 Body brownish or reddish yellow, gaster and occipital region darker (p. 470), . . . . . **imparis testacea**

*Prenolepis imparis* (Say).—This species appears predominantly in woodlands built upon a substratum of clay. Small craters mark the entrance to the nests, and a short distance below the surface are domed chambers where the brood and repletes may be found. The gorged condition of the latter individuals results from imbibing the secretions of aphids, and recalls the honey ants of the Southwestern United States in which the replete has evolved further.

Localities: Palos Park, Ill.; Orland Park, Ill.; Volo, Ill.; Cary, Ill. (Schweitzer); Chesterton, Ind.; Ogden Dunes, Ind.; Dune Acres, Ind.; Three Rivers, Mich.; Lake Geneva, Wis. (Lowrie); Miller, Ind. (Miller).

*Prenolepis imparis* var. *lestacea* Emery.—The habitat requirements are the same as for the typical *imparis*, but this variety has been encountered less frequently.

Localities: Palos Park, Ill.; Miller, Ind.

### ***Lasius* Fabricius**

#### KEY TO THE SPECIES

1. Maxillary palpi 6-jointed . . . . . 2  
Maxillary palpi 3-jointed . . . . . (subgenus *Acanthomyops*) 7
2. Terminal joints of maxillary palpi long, subequal; eyes medium-sized; epigaic . . . . . (subgenus *Lasius*) 3  
Terminal joints of maxillary palpi successively diminishing toward the apex; eyes minute; hypogaic . . . . . (subgenus *Chthonolasius*) 4
3. Scapes and legs without erect hairs (p. 470) . . . . . **niger alienus americanus**  
Scapes and legs beset with erect hairs (p. 471) . . . . . **niger neoniger**
4. Tips of scapes not quite reaching to posterior corners of the head (p. 471), . . . . . **brevicornis**  
Tips of scapes surpassing posterior corners of head . . . . . 5
5. Tips of antennal scapes but slightly surpassing posterior corners of head; color pale yellow (p. 471) . . . . . **flavus nearcticus**  
Tips of antennal scapes extending some distance beyond posterior corners of head; color brownish yellow . . . . . 6
6. Gaster subopaque; with appressed hairs (p. 471) . . . . . **umbratus mixtus aphidicola**  
Gaster smooth and shining; without appressed hairs (p. 471), . . . . . **umbratus mixtus speculiventris**
7. Petiole low and blunt above in profile (p. 471) . . . . . **latipes**  
Petiole higher, thin, and acute above in profile . . . . . 8
8. Penultimate joints of distally incrassated antennal funiculus somewhat broader than long; gaster with abundant long hairs (p. 472) . . . . . **claviger**  
Penultimate joints of but slightly incrassated funiculus not broader than long; gaster with sparse long hairs (p. 472) . . . . . **interjectus**

*Lasius niger alienus americanus* Emery.—This is an exceedingly common ant and is found from dry, open pastures to the interior of climax forests. It will nest in most stages of logs and under sticks or stones or other suitable cover. The colonies are large, hence they are able to produce numerous winged males and females which appear in late summer. The workers have often been observed tending aphids for their secretions, and the species also cultivates the corn root aphid in its subterranean passages. As a result of this habit it is of considerable importance as an agricultural pest.

Localities: New Lenox, Ill.; Palos Park, Ill.; Hadley, Ill.; Volo, Ill.; Ogden Dunes, Ind.; Dune Acres, Ind.; Chesterton, Ind.; Hammond, Ind.; Smith, Ind.; Lakeside, Mich.; Coloma, Mich. (Ivaska); Three Rivers, Mich.; Lake Como, Wis. (Lowrie).

*Lasius niger* var. *neoniger* Emery.—This variety, though very abundant and widespread, I have not collected from the beech-maple forests or subelimax. *Neoniger* overlaps with *americanus* in many habitats but replaces the latter in pioneer dunes, and is the commonest ant in the lawns and gardens of urban dwellings. Nests have been located under stones and in some decaying logs.

Localities: Chicago, Ill.; Volo, Ill.; New Lenox, Ill.; Waukegan, Ill.; Momence, Ill.; Pine, Ind.; Ogden Dunes, Ind.; Dune Acres, Ind.; Chesterton, Ind.; Lakeside, Mich.; Coloma, Mich. (Ivaska).

*Lasius (Chthonolasius) brevicornis* Emery.—It is most often found under logs or stones in well drained situations. The indications from my records are that it is a rare to uncommon species.

Localities: Willow Springs, Ill. (Windsor); Dune Acres, Ind.

*Lasius (Chthonolasius) flavus nearcticus* Wheeler. —In the majority of cases this ant occurred in moist, shady woods and under logs and stones. Its extremely pale yellow color correlated with its subterranean habits make the species easy to distinguish.

Localities: Ogden Dunes, Ind. (Lowrie, Gregg); Smith, Ind.; Lakeside, Mich.

*Lasius (Chthonolasius) umbratus mixtus aphidicola* Walsh —This is the most abundant of the hypogaecic species of *Lasius*. Its colonies are usually large and are placed in and under logs or rotting stumps.<sup>6</sup> As indicated by the varietal name, they have a propensity for cultivating aphids and coccids which are sometimes present in large numbers. Winged males and females of *aphidicola* were taken from nests in April, August, September and October.<sup>7</sup>

Localities: Palos Park, Ill.; New Lenox, Ill.; Aurora, Ill. (Dybas); Chicago, Ill.; Miller, Ind.; Hammond, Ind.; Chesterton, Ind.; Smith, Ind. (Kurtz, Gregg); Lakeside, Mich.; Lake Geneva, Wis. (Lowrie); Madison, Wis. (Collector ?).

*Lasius (Chthonolasius) umbratus mixtus speculiventris* Emery.<sup>8</sup>—Much rarer than the preceding variety.

Localities: New Lenox, Ill.; Volo, Ill.; Smith, Ind.

*Lasius (Acanthomyops) latipes* Walsh. —Members of the subgenus *Acanthomyops* are rare in the Chicago Region although they seem to be more common in the Eastern States. A colony of *latipes* in dune sand was preparing to swarm in the late afternoon, and a number of the Beta females were captured as well as males and workers (August).

Localities: Waukegan, Ill.; Hessville, Ind. (Wenzel)

<sup>6</sup>A group of nests in one of the filled ponds of the Gary Pond Series at Hammond was constructed of rich muck and stood two to three feet high with diameters of somewhat smaller dimension. The ground about them was doubtless subject to flooding at certain periods. (Located by Mr. S. A. Windsor.)

<sup>7</sup>In my possession are two cases of the temporary parasitism of *Lasius umbratus mixtus aphidicola* on *Lasius niger alienus americanus*, and one case on *Lasius niger neoniger*. In each instance, however, only the invading queens of the parasite were obtained and none of their progeny had apparently developed.

<sup>8</sup>A single doubtful specimen of *Lasius umbratus minutus* Emery from Chicago, Illinois, was identified too late to be fitted into the key. This subspecies may be distinguished from the others by its small size (average less than 4 mm.) and the dense pubescence with erect hairs on the gaster. The gaster is subopaque.



*Lasius (Acanthomyops) claviger* Roger.—Localities: Momence, Ill.; Lake Geneva, Wis. (Lowrie); Three Rivers, Mich.

*Lasius (Acanthomyops) interjectus* Mayr.—Under stones in open woodlands or forest margin. Two colonies only were discovered.

Localities: Palos Park, Ill.; New Lenox, Ill.

## Formica Linnaeus

### KEY TO THE SPECIES

1. First funicular joint of worker and female about as long as the second and third joints taken together . . . . . (subgenus **Proformica**) 2
- First funicular joint of worker and female distinctly shorter than the second and third taken together . . (subgenus **Formica** and subgenus **Neoformica**) 3
2. Antennal scapes with erect hairs (p. 473) . . . . . **neogagates lasioides vetula**
- Antennal scapes without erect hairs (p. 473) . . . . . **neogagates neogagates**
3. Clypeus emarginate or notched in the middle of the anterior border . . . . . 4
- Clypeus not emarginate . . . . . 7
4. Gaster black, head and thorax deep red . . . . . 5
- Gaster brown, head and thorax light red . . . . . 6
5. Front and vertex more or less infuscated (p. 473) . . . . . **sanguinea aserva**
- Front and vertex not infuscated (p. 473) . . . . . **sanguinea rubicunda**
6. Hairs almost always absent from the thoracic dorsum and petiolar border, short and few on the head and gaster (p. 473) . . . . . **sanguinea subnuda**
- Hairs present on the thoracic dorsum, longer and more numerous on the head and gaster (p. 473) . . . . . **sanguinea subintegra**
7. Posterior border of head broadly excised; sides of head subparallel . . . . . 8
- Posterior border of head straight or convex, or at most very feebly excised; sides of head converging anteriorly . . . . . 9
8. Pronotum and mesonotum with coarse yellow hairs; posterior half of head black (p. 474) . . . . . **ulkei**
- Pronotum and mesonotum without hairs; head completely red (p. 474), . . . . . **exsectoides exsectoides**
9. Body of worker stout; head of largest individuals not longer than broad. Funicular joints 2-3 longer and more slender than joints 6-8. Superior border of petiole usually sharp. Color light or dark red with brown or black gaster . . . . . 10
- Body of worker slender; head of largest individuals distinctly longer than broad. Funicular joints 2-3 at most slightly more slender than joints 6-8. Petiole narrow with superior border blunt. Color black, brown or yellowish brown . . . . . 15
10. Female smaller or not larger than the largest workers (p. 474) . . . . . **nepticula**
- Female larger than the largest workers . . . . . 11
11. Erect hairs absent on the gula and upper surface of head and thorax (p. 474) . . . . . **truncicola integra**
- Erect hairs present on the gula and upper surface of head and thorax . . . . . 12
12. Eyes hairless (p. 474) . . . . . **truncicola obscuriventris gymnomma**
- Eyes hairy . . . . . 13
13. Head and thorax of small workers scarcely or not at all darker than in the largest workers (p. 474) . . . . . **truncicola obscuriventris**
- Head and thorax of small workers decidedly darker than in the largest workers . . . . . 14
14. Thorax of large workers bright red like the head or at most very feebly infuscated; pubescence on gaster dense (p. 474) . . . . . **rufa aggerans**
- Thorax of large workers deeply infuscated; pubescence on gaster more dilute (p. 475) . . . . . **rufa aggerans melanotica**
15. Median joints of funiculus less than  $1\frac{1}{2}$  times as long as broad; scapes distinctly curved at the base. Thorax of worker rather short; petiolar scale flattened posteriorly . . . . . 16
- Median joints of funiculus more than  $1\frac{1}{2}$  times as long as broad; scapes scarcely curved at the base. Thorax of worker longer; petiole convex posteriorly . . . . . (subgenus **Neoformica**) 18



*Formica ulkei* Emery.—This ant is characteristic of the boreal fauna, and according to Wheeler is peculiar to the Canadian Zone. It is present in the vicinity of Chicago in very local spots, and it is probable that our collections represent the southern edge of its range. A striking aggregation of nests at Palos Park was visited many times, and it has furnished much material for other investigators. Several stations have yielded specimens of *ulkei*, as indicated, but a group of nests reported from Palatine, Illinois, was not my privilege to observe. Where a large number of colonies occupy a circumscribed area, the correlation of their distribution with the forest margin habitat is almost diagrammatic.

Localities: Palos Park, Ill.; Waukegan, Ill. (Lowrie, Gregg); Volo, Ill.; Dune Acres, Ind.; Smith, Ind. (Maina); Lakeside, Mich.

*Formica exsectoides exsectoides* Forel.<sup>9</sup>—This species is closely allied to *ulkei* and is the only other example of the *exsecta* group known to me in the area. It is apparently much commoner in the Eastern States, and efforts to locate nests at the head of the lake have been rewarded with meager returns.

Localities: New Lenox, Ill.; Palos Park, Ill.; Tremont, Ind. (Wiersinski); Lakeside, Mich.; Chicago Heights, Ill.

*Formica nepticula* Wheeler.—The *microgyna* group, to which this species belongs, is practically impossible to determine without the queens as it is the disparity in stature of the female caste that differentiates these ants from species of the *rufa* group. An adequate series of individuals came from a single colony in the prairies southwest of the city.

Localities: Chicago, Ill.

*Formica truncicola obscuriventris* Mayr.—Ants of the *rufa* group are usually exemplified by this form, but the others appear in varying degrees of abundance. *Obscuriventris* is commonest in the wooded parts of the dunes and especially in the more mesophytic portions. Its nests ramify through the leaf-litter, and the exact entrance leading to the main galleries is not easy to discern. They have been recovered from the soil beneath badly decayed stumps.

Localities: Waukegan, Ill.; Ogden Dunes, Ind.; Dune Acres, Ind.; Tremont, Ind.; "Indiana Sand Dunes" (Dropkin).

*Formica truncicola obscuriventris gymnomma* Wheeler.—Localities: Waukegan, Ill.; Momence, Ill. (Lowrie).

*Formica truncicola integra* Nylander.—Found alone in the prairies southwest of the city.

Localities: Chicago, Ill.; Harvey, Ill.

*Formica rufa aggerans* Wheeler.—This species and the following variety were first noticed in the dry, black oak woodland of the Waukegan Dunes. The mounds are scarcely raised above the surrounding ground level, and a peculiar feature of the nest is its almost

<sup>9</sup>*Formica exsectoides exsectoides davisi* Wheeler has been found in the collection since composition of this paper, and was obtained from forest margin at New Lenox, Illinois. It may be separated from *exsectoides* by the infuscation of the vertex, occiput and pro- and mesonotum.

entire construction of thatch or small twigs heaped into the center and extending some distance into the interior of the colony.

Localities: Waukegan, Ill.; Palos Park, Ill.

*Formica rufa aggerans melanotica* Emery.—As indicated in the key, this is a very dark variety of *aggerans*. It occurs in essentially the same situations as the latter, but was not seen on clay.

Localities: Waukegan, Ill.

*Formica cinerea cinerea neocinerea* Wheeler.—The predominate formicid of the prairies and meadows is this member of the *fusca* group. Its mounds are low and usually a foot or two in diameter, and in some spots they are but a few paces apart. One astonishing nest measured approximately six feet across. Occasionally, a high dome may be built in low lying grasslands, but a correlation of this style of nest with inundation of the habitat was not verified. The species serves as host for some of the slave-making ants.

Localities: Chicago, Ill.; Palos Park, Ill.; Orland Park, Ill.; Waukegan, Ill.; Volo, Ill.; Smith, Ind.

*Formica fusca fusca subsericea* Say.—Aside from the varieties of *Lasius niger*, this is our commonest ant, and as would be expected, it tolerates a wide range of environmental fluctuations. It has been observed to forage over hot sand in the pioneer stages of dune succession, and is equally adjusted to the shade of ravine forests. Many workers have been seen on the branches and foliage of trees or upon the understory where they actively search the secretions of aphids. As with *neocinerea*, this ant is frequently parasitized by species of slave-makers.

Localities: Palos Park, Ill.; Chicago, Ill.; New Lenox, Ill.; Waukegan, Ill.; Volo, Ill.; Momence, Ill.; Ogden Dunes, Ind.; Dune Acres, Ind.; Lakeside, Mich.; Three Rivers, Mich.; Lake Como., Wis. (Lowrie).

*Formica fusca fusca subaenescens* Emery.—This variety of *fusca* is much rarer than the preceding one, and in addition is relatively stenokous. Moist woodlands and especially the advanced stages of logs are its places of abode. The shiny gaster distinguishes it from *subsericea*.

Localities: Palos Park, Ill.; Chicago, Ill.; Volo, Ill. (Lowrie, Gregg); Ogden Dunes, Ind.

*Formica (Neoformica) pallidefulva schaufussi* Mayr.—The four ants of this group in our fauna are excellent indicators of the black oak associates in dune succession, for under a high percentage of the sticks and logs in these woods one may find the openings to their inconspicuous nests. The prickly pear cactus (*Opuntia*) often conceals a formicary under its orbicular stems. A few colonies were noticed in pastures and grasslands. The workers seem to be very timid, and they are used extensively as slaves by the different species of *sanguinea*. The subspecies *schaufussi* is less common than others of the group, but it is the largest. The characters given in the key, while somewhat variable, are nevertheless the most satisfactory. A series of specimens is indispensable for taxonomic determination as there is considerable overlap among individuals of one colony.

*Polygerus lucidus* Mayr.—This is the typical species of the Eastern States, but it is found as far west as the Great Plains and therefore overlaps with *breviceps*. I have not yet obtained individuals from the Chicago Area, but *lucidus* has been reported from Pine, Indiana, by Dr. Wheeler and its presence will doubtless be confirmed with further search.

**Camponotus Mayr****KEY TO THE SPECIES**

1. Anterior clypeal border with a distinct, median emargination,  
(subgenus **Myrmentoma**) 2  
Anterior clypeal border without such an emargination,  
(subgenus **Camponotus**) 5
2. Cheeks and clypeus with elongate, piligerous foveolae . . . . . 4  
Cheeks and clypeus without such foveolae . . . . . 3
3. Body black, except prothorax which is dark red (sometimes infuscated),  
(p. 477) **caryae caryae nearcticus**  
Body dark, but thorax and at least basal half of first gastric segment yellowish  
red (sometimes mottled), (p. 477) **caryae caryae tanquaryi**
4. Brownish yellow, gaster paler with brown bands (p. 477) **caryae subbarbatus**  
Head blackish brown, thorax red (p. 477) **caryae discolor clarithorax**
5. Head of worker major smooth and shining behind; color at least in part light  
red or yellow. 6  
Head of worker major opaque or feebly shining behind; color black or black  
and darker red 7
6. Body yellow or light red throughout (p. 477) **castaneus**  
Head at least dark brown or black (p. 477) **castaneus americanus**
7. Gaster opaque or subopaque; pubescence on gaster long. . . . . 8  
Gaster shining, with short sparse pubescence; thorax deep red (p. 478),  
**herculeanus ligniperda noveboracensis**
8. Color black throughout; pubescence white (p. 478) **herculeanus pennsylvanicus**  
Posterior portion of thorax, petiole, legs and base of gaster reddish yellow;  
pubescence and pilosity yellow (p. 478),  
**herculeanus pennsylvanicus ferrugineus**

*Camponotus (Myrmentoma) caryae caryae nearcticus* Emery.—The ants of the *caryae* group are not as abundant as other *Camponoti*, but can be found if one is careful to examine dead twigs and early stages of logs. They seem to exhibit some preference for rather dry wood. The variety *nearcticus* is the commonest form and is present in black oak dunes and climax forest chiefly.

Localities: Waukegan, Ill.; Momence, Ill.; Aurora, Ill. (Dybas); Chesterton, Ind.; Dune Acres, Ind.; Tremont, Ind.; Beverly Shores, Ind. (Dybas); Smith, Ind.

*Camponotus (Myrmentoma) caryae caryae tanquaryi* Wheeler.—Localities: Palos Park, Ill.; Smith, Ind.

*Camponotus (Myrmentoma) caryae subbarbatus* Emery.—Localities: Smith, Ind.; Lakeside, Mich. (Miller).

*Camponotus (Myrmentoma) caryae discolor clarithorax* Emery.<sup>10</sup>—Localities: Waukegan, Ill.; Lakeside, Mich.; Ogden Dunes, Ind.

*Camponotus castaneus* Latreille.—This attractive species nests in logs and the soil under them in the black oak woods of the dunes. The colonies are of moderate size.

Localities: Momence, Ill. (Lowrie, Gregg); Dune Acres, Ind.; Beverly Shores, Ind. (Dybas).

*Camponotus castaneus americanus* Mayr.—According to the few data obtained, this ant inhabits moist oak forests on clay.

Localities: Palos Park, Ill.; Hadley, Ill.

<sup>10</sup>*Camponotus (M.) caryae discolor* Buckley, another addition for the region, was collected in a dune heath at Waukegan, Illinois. Differs from *clarithorax* in having the head and thorax both bright red.

*Camponotus herculeanus pennsylvanicus* De Geer.—This is the ubiquitous "carpenter ant" that attacks live trees as well as all but the final stages of log decay. The wood is chewed and excavated probably by the worker majors or soldiers, and is deposited outside the nest as sawdust. Their food consists in large measure of the excretions of aphids, and is sought by the medium and small sized workers foraging over the leaves and twigs of trees. Incipient colonies containing a dealated female and her brood or first workers (very small) are frequently revealed when the loose bark of a fallen tree is removed. All forested zones about Chicago yielded specimens, and occasionally the ant may invade houses.

Localities: Palos Park, Ill.; New Lenox, Ill.; Momence, Ill.; La Salle, Ill. (Miller); Tonica, Ill. (Lowrie); Miller, Ind.; Ogden Dunes, Ind.; Dune Acres, Ind.; Chesterton, Ind.; Smith, Ind.; Lakeside, Mich.; Three Rivers, Mich.

*Camponotus herculeanus pennsylvanicus ferrugineus* Fabricius.—The red of this variety contrasts strikingly with the deep black of the typical *pennsylvanicus*. It is a much less common ant and is found primarily in rich, shady woods. Its preference seems to be for middle and late periods in rotting logs and stumps.

Localities: Orland Park, Ill.; Hadley, Ill.; Smith, Ind.; Lakeside, Mich.

*Camponotus herculeanus ligniperda noveboracensis* Fitch.—The species surpassed *pennsylvanicus* in the variety of niches occupied, yet was not as frequently encountered. While *pennsylvanicus* reaches into the Gulf States, *noveboracensis* overlaps its distribution only in the Northern States, and is said to live at somewhat higher elevations than the former. This may account in part for our records of the ant from tamarack bogs, which are boreal in character.

Localities: New Lenox, Ill.; Volo, Ill.; Miller, Ind.; Dune Acres, Ind.; "Indiana Dunes," Morocco, Ind. (SeEVERS); Smith, Ind.

## POSTSCRIPT

Since this paper went to press, two more species have been found, namely: *Formica (Proformica) neogagates neogagates morbida* Wheeler and *F. (P.) neogagates neogagates vinculans* Wheeler. With the eighty-five species listed in Table I, plus the five additional accounted for here and in the footnotes, there are ninety forms which have been examined. Added to this, the five ants recorded by Talbot, but not represented in my collection, bring a total of ninety-five species (including subspecies and varieties) which are known to occur in the Chicago Region.

Dr. Creighton has recently revised the forms of *Formica rufa* in which varieties are eliminated and four new subspecies are described, et cetera.<sup>11</sup> Unfortunately, it is impractical to incorporate such changes into the present report, but the writer is in agreement with them, and no doubt similar revisions in other groups of *Formica* would be a distinct advance.

<sup>11</sup>Creighton, W. S. 1940. A revision of the North American variants of the ant *Formica rufa*. Amer. Mus. Nov. No. 1055, pp. 10.

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## CORRECTIONS (ERRORS AND OMISSIONS)

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Corrections are limited to critical omissions and serious errors.—The Editors.

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**Ewing and Fox.** Book Notice, p. 336. Vol. 36, 1943. Publications on American Fleas were by Baker 1904, not "Parker" and Jellison. Fox wrote on "Fleas of Eastern United States" not "Western United States."

**Rau, Phil.** 1943. The nesting habits of certain Sphecoid wasps of Mexico. *Annals* 36 (4): 652. In the heading, *Macrosiagon* sp. probably *excavatum*, near bottom of page 652, delete the words "sp. probably." Additional specimens sent recently to Mr. H. S. Barber have definitely established the beetle's identity as *M. excavatum* Champion.

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